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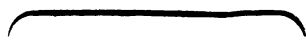
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THE FIELD PRACTICE
OF
LAYING OUT CIRCULAR CURVES
FOR
RAILROADS.

BY JOHN C. TRAUTWINE, C.E.,
OF THE UNITED STATES.

*Extracted, and sold separately, from Simms's work on Levelling,
being pp. 139—215.*

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1856.

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PREFACE.

THIS little volume has been prepared almost entirely with reference to the wants of young men who desire to qualify themselves for field service in an Engineer Corps. On that account the plainest language has been used to render the subject intelligible,—dispensing with mathematical brevity.

The Table of Natural Sines and Tangents to single minutes, in a form sufficiently portable for field use, will supply a want which is frequently experienced, not only in the operation of laying out curves, but on many other occasions.

One object in preparing it, was to furnish the profession with a Table that should be not only portable, but *absolutely reliable*. Those whose occupations compel them to resort to the Tables in common use, must have frequently experienced the embarrassment which attends the inaccuracies to which they are all subject. So long as a Table is known to contain a single error, the position of which is not ascertained, its employment is attended with doubt in every instance in which we are obliged to refer to it.

As Hutton's Tables of Natural Sines and Tangents are those most in use among the profession, it will be desirable to those persons who possess them, to be able to correct the following errors, which I detected in comparing them.

In Hutton's Tables, Fifth Edition, 1811.

Sine of $6^{\circ} 8'$, for $\cdot 1063425$, read $\cdot 1068425$.

Page 328, at top, for 25 Deg., read 40 Deg.

Tangent of $44^{\circ} 60'$, for $\cdot 1000000$, read $1\cdot 000000$.

Tangent of $41^{\circ} 60'$, for $\cdot 8994040$, read $\cdot 9004040$.

PREFACE.

In Dr. Gregory's corrected Edition (the 8th) of Hutton's Tables, 1838.

Sine of $49^{\circ} 14'$, for $\cdot 7576751$, read $\cdot 7573751$.

In Hassler's Tables, 1830.

Sine of $78^{\circ} 24'$, read $\cdot 9795752$.

Sine of $20^{\circ} 60'$, „ $\cdot 3583679$.

Sine of $66^{\circ} 19'$, „ $\cdot 9157795$.

Sine of $56^{\circ} 39'$, „ $\cdot 8353279$.

Sine of $55^{\circ} 20'$, „ $\cdot 8224751$.

Sine of $53^{\circ} 4'$, „ $\cdot 7993352$.

Sine of $48^{\circ} 12'$, „ $\cdot 7454760$.

Sine of $45^{\circ} 3'$, „ $\cdot 7077236$.

The discrepancies of 1 in the 7th decimal, are not considered as errors, as they are occasioned by a neglect of the value of the 8th decimal. For calculating curves, it is not necessary to use more than 4 decimals.

It is scarcely necessary to remark that, beyond 44° , the Sines, Tangents, &c., are read *upwards*, from the bottom of the page, using the corresponding column of minutes. To find the sine of an angle exceeding 90° , subtract the angle from 180° , and take out the sine of the remainder—because the sine of an angle, and that of what it wants of 180° , are the same.

J. C. T.

THE FIELD PRACTICE OF LAYING OUT CIRCULAR CURVES FOR RAILROADS.

ARTICLE I.

PRINCIPLES OF LAYING OUT CURVES.

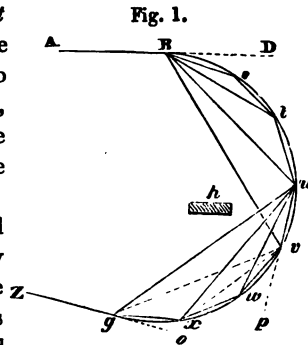
METHOD I.

To lay out a Curve by means of Tangential Angles.

IF from any point B, fig. 1, in a straight line AD, we lay off any number of equal angles, as DBs, sBt, tBu, uBv, &c., and at the same time make the chords Bs, st, tu, uv, &c., equal to each other, then the points B, s, t, u, v, &c., will be situated in the circumference of a circle, which is tangential to the line AD at the point B.

The first of these angles, DBs, is called the *tangential angle*, as being that by which the curve is connected with the tangent AD; but inasmuch as the others are all equal to it, they also are called tangential angles.

If any obstacle, as *h*, should prevent our seeing from B farther than to *v*, the curve may be continued by removing the instrument to *u*, the point preceding *v*: thence sighting first on *v*, continue to lay off additional tangential angles *vuw*, *wux*, &c., as before. Or else, moving the instrument to *v* itself instead of to *u*, sight back to *u*, and lay off first the exterior angle *p v w*, equal to *double* the tangential angle, and afterward continue the tangential angles *w v x*, *x v g*, &c., as before, to the end of the curve.



Finally, in order to pass from the end of the curve at g , on to a tangent gz , place the instrument at g , and sighting back to x , lay off the tangential angle xgo ; then og continued toward z will be the required tangent. (See Art. IV.)

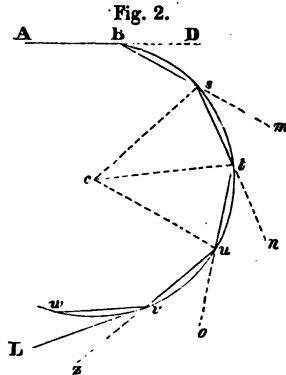
For the tangential angles corresponding to different radii, and chords of 100 feet, see page 160.

ARTICLE II.

METHOD 2.

To lay out a Curve by means of Deflection Angles.

Fig. 2. First, having, as in method 1, laid off a tangential angle DBs , and measured the chord Bs , remove the instrument to the end s of the chord, and make the exterior angle $ms t$ equal to *twice* the tangential angle, and measure the chord st ; and so on at the other points t, u, v , &c., making each of the exterior angles ntu, ouv , equal to twice the tangential angle, and all the chords equal; then will the points B, s, t, u, v , &c., be in the circumference of a circle which is tangential to the line AD at the point B , as by the first method.



But if, at any of these points, as v , we wish to pass off to a tangent vL , employ at that point the *tangential* angle zvL , equal to half the deflection angle $zv w$. (See Art. IV.)

These exterior angles, included between any *chord* and the extension of the preceding *chord*, are called *deflection angles*, or *angles of deflection*, or *angles of curvature*. In any given circle, the angle of deflection is always precisely double the tangential angle, supposing the chords to be equal. At page 160, we give tables of the angles corresponding to circles of different radii, embracing the limits of railroad practice; and calculated for chords 100 feet in length, that being the usual length for a measuring chain on public works.

N. B. The deflection angle of any curve is equal to the angle $t c u$, or $t c s$, &c., at the centre of the circle, subtended by one of the equal chords tu or ts . This angle at the centre, so subtended, is called the *central angle*. The tangential angle, being always half the deflection angle, is, of course, always half the central angle.

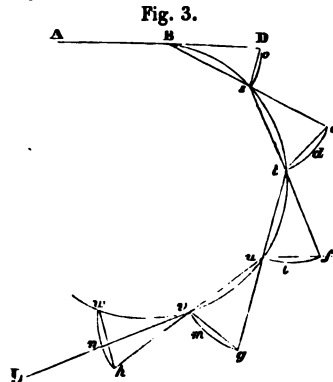
ARTICLE III.

METHOD 3.

To lay out a Curve by Eye.

The *deflection* angles, fig. 3, est , ftu , guv , hvw , &c., being double, the *tangential* angle DBs , the *arcs* edt , fiu , $gm v$, hnw , &c., are double the *arc* Dcs , since the arcs of circles are proportionate to the angles which they subtend; but the *chords* et , fu , gv , hw , &c., are *not* double the *chord* Ds , since the chords of arcs are not proportionate to the arcs, or to the angles which they subtend.

The chords et , fu , gv , hw , &c., which subtend the deflection angles, are called *deflection distances*; and the chord Ds , which subtends the tangential angle, is called the *tangential distance*.



But although, in any given circle, the deflection distance is not *truly* twice the tangential distance, yet the difference is so trifling in large railroad curves, with chords of but 100 feet, that it may generally be neglected in curves of more than 300 feet radius.

In our tables the *precise* length of both will be found for different radii, and for chords of 100 feet.

Having these respective distances, we may frequently trace a curve on the ground by the eye only, with very tolerable accuracy, sufficient for guiding the excavations and embankments, especially on nearly level ground. Suppose, for instance, it be required to lay out in this manner a curve of 5730 feet radius.

First, find by the table, page 160, or by Art. XVI., the deflection distance et or fu , &c., corresponding to a radius of 5730 feet for a chord of 100 feet—viz., 1.745 foot; and also the tangential distance ds , .873 of a foot.

Then from the starting point B, and in line with A B, measure B D, equal 100 feet, and put a pin at D. Also from B, measure the chord B s, equal 100 feet; at the same time measuring with a graduated rod, from the pin D, the *tangential* distance D s, equal to .873 of a foot; and place a stake at s. The pin at D may then be removed.

Next, make se equal to 100 feet, placing a pin at e, precisely in line with s B; also from s measure st , equal 100 feet; at the same time measuring with the rod, from the pin e, the *deflection* distance et , equal

to 1.745 foot. Place a stake at t , and remove the pin at e . In this manner proceed to find other points as far as the end of the curve at v .

In order to pass the curve, as at v , to a tangent vL , proceed as before, only using the tangential distance $h\pi$, instead of the deflection distance hw . (See Art. IV.)

This method is abundantly accurate for laying out curves on a canal or common road; and will occasionally answer very well, when carefully performed, for railroad curves, in the absence of an instrument. Thin straight rods, iron-pointed, and a plumb line should be used for ranging the points in the latter case.

The transit instrument is the best for tracing curves, and running lines generally. I prefer the graduations to run from the same zero, right and left, to 180° each way. There should be two verniers, graduated to minutes; by their means half or even quarter minutes may generally be estimated with considerable certainty. The telescope, revolving in a vertical plane, greatly expedites the laying off of exterior angles, after having first sighted backward to the point behind.

The verniers are sometimes graduated to hundredths of a degree; and this division is, in certain cases, the best; but for *general* purposes, the division into minutes is to be preferred, as all the printed tables of sines, tangents, &c., are calculated for that division.

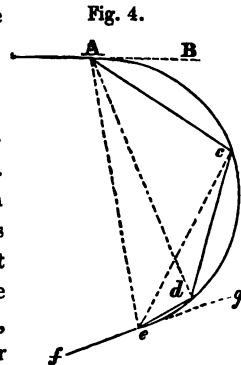
ARTICLE IV.

On Sub-Chords.

We have hitherto spoken of curves as if they were composed of equal chords, each of 100 feet in length. It frequently happens, however, that at the end of a curve, as at e , fig. 4, we are obliged to use a shorter or sub-chord de , in order to unite properly with the tangent ef .

In that case, and *when using Method 1, Art. I., of laying off curves by means of tangential angles*, we must, in order to fix the point e , lay off a *sub-tangential* angle dAe , as much smaller than the entire tangential angle BAc , or cAd , &c., as the sub-chord de is smaller than an entire 100 feet chord, ac , cd , &c. Thus, if the sub-chord be one-half, or one-fourth, &c., of the entire chord, the sub-tangential angle must be one-half, or one-fourth, &c., of the entire tangential angle.

This method is not mathematically exact, for the reason stated in Art. III. (viz., that the *chords* subtending different angles are not propor-



tional to those angles); yet, for curves of 300 or more feet radius, and with chords not exceeding 100 feet in length, the error is not observable in practice.

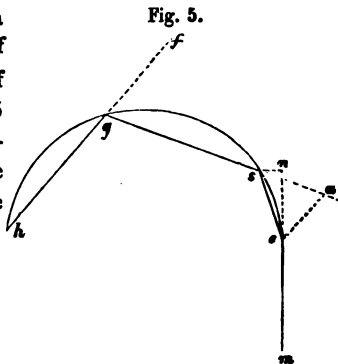
In like manner, when we pass off from a sub-chord, as at e , to a second tangent, ef , we must place the instrument at e , and lay off the same sub-tangential angle deg ; or, which is better, take sight from e to c , and lay off the angle ceg , equal to the *sum* of a tangential and the sub-tangential angle.

But when using *Method 2, Art. II., of deflection angles, or Method 3, Art. III., of deflection distances*, we may calculate the sub-deflection angle ase , fig. 5, and sub-deflection distance ae , formed between a sub-chord se , and the extension sa , of an entire chord gs , with sufficient accuracy for curves of 300 or more feet radius, and chords of not more than 100 feet, thus:

Rule.—Say, As an entire chord of 100 feet is to the sub-chord se , so is the deflection angle of the curve to a certain angle. Add these two angles together and divide their sum by 2, for the sub-deflection angle ase of the sub-chord.

Example.—The curve, fig. 5, has a radius of 319.6 feet, and an angle of deflection, fgs of 18° for chords of 100 feet. The sub-chord se is 25 feet in length: what is the sub-deflection angle ase ; and also the sub-deflection distance ae , for the sub-chord se ?

| | Chord. | Sub-Chord. |
|----------|-------------------------------|--------------------|
| Here, as | 100 | is to 25, |
| | Def. An. of 100 feet cord. | Certain Angle. |
| So is | 18° | to $4^\circ 30'$. |



The sum of these two angles, 18° and $4^\circ 30' = 22^\circ 30'$, the half of which is $11^\circ 15'$, the required sub-deflection angle ase .

Again, to find the sub-deflection distance ae of the sub-chord se ; take from the table of sines the natural sine of *one-half* the sub-deflection angle ase , just found. Multiply this natural sine by 2, and multiply that product by the length of the sub-chord.

Example.—The sub-deflection angle is $11^\circ 15'$; one half of it is $5^\circ 37\frac{1}{2}'$, the tabular natural sine of which is .0979, which, multiplied by 2, gives .1958; this, multiplied by the sub-chord, 25 feet, gives 4.895 feet, the required sub-deflection distance ae .

Finally, to find the sub-tangential distance sn , by means of which to

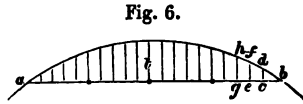
pass from e to the tangent em , say, As 10000 is to the square of the sub-chord in feet, so is the *tangential* distance for 100 feet chord, to $s\pi$. In this instance, we have, As 10000 is to 625, so is 15.69 feet to .980 foot, or $s\pi$.

ARTICLE V.

Ordinates for Entire Chords.

It would be both tedious, and liable to inaccuracy, to attempt to fix all the necessary points in railroad curves by the foregoing means, which are employed only for entire chords, or for such sub-chords as may be required at the ends of curves.

The best method is to stretch a piece of twine ab , fig. 6, 100 feet long, between two adjacent chord-stakes, and measure off as nearly as may be at right angles to it, with a graduated rod, the previously calculated ordinates, cd , ef , gh , &c., placing pegs at d , f , h , &c.* Our table of ordinates, page 162, is calculated for distances apart bc , ce , eg , &c., of 5 feet; and for all curves likely to occur in practice. The 5 feet distances on the twine should be marked by knots or otherwise; and those at the centre, and half way between it and the ends, be further distinguished by tying on pieces of tape.



The 5 feet distances are only used (after the excavations and embankments are finished) for placing pegs to guide the laying of the rails, and then only for very sudden curves; for those of large radii, distances of 10 feet are quite sufficient, or even 25 feet for very easy curves. For guiding the curves of the cuttings and fillings, it is not necessary to place the stakes nearer than 50 feet apart; unless for those of less than about 1000 feet radius, when they may be placed 25 feet apart. Ordinates for radii intermediate of those in the table, may either be calculated by the rules given further on, or they may be taken proportionally intermediate of the tabular ones, with sufficient accuracy for practice.

Ordinates for Sub-Chords.

These may readily be calculated *approximately enough for railroad practice*, for curves of over 300 feet radius, and for chords not exceeding 100 feet, thus: In a circle of given radius, not less than about 300 feet, the ordinates of an entire 100 feet chord may be assumed to be to those of a sub-chord, as the square of the chord is to the square of the sub-chord.

* On the tops of these stakes small tacks are driven, to define the precise point in the curve.

In all our tables the chord is supposed to be 100 feet, the square of which is 10000; the rule therefore becomes, As 10000 feet : to square of sub-chord in feet :: Ord. of Chord : Ord. of Sub-chord *approximately*.

Example.—In a curve of 5730 feet radius, the middle ordinate of a 100 feet chord is .218 of a foot; what will be the length of the middle ordinate of a sub-chord of 50 feet? Here,

| Sq. of 100 ft. : | Sq. of 50 ft. :: | Mid. Ord. of Chord. | : | Mid. Ord. Sub-Chord <i>approximately</i> . |
|------------------|------------------|------------------------|---|---|
| 10000 | : 2500 :: | .218 ft. | : | .0545 ft. |

And so of any other ordinate, always supposing the chord and sub-chord to be divided into the *same number of parts*.

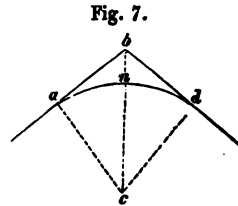
ARTICLE VI.

Having given the angle $a b d$, fig. 7, it is required to find the point a or d , at which to commence a curve of given radius.

Rule.—Subtract half the angle $a b d$ from 90° ; the remainder will be the angle $b c a$ or $b c d$. From the table of tangents take the natural tangent of $b c a$, and multiply it by the given radius; the product will be $b a$ or $b d$.

Example.—Let the angle $a b d$ be 120° , how far from b must we begin, at a or d , to lay out a curve $a n d$, of 2865 feet radius?

Here, half of the angle $a b d = 60^\circ$, which taken from 90° leaves the angle $b c a = 30^\circ$. The natural tangent of $30^\circ = .5773$, which, multiplied by the radius of 2865 feet, gives 1653.96 feet for $b a$ or $b d$. (See Art. XII.)



ARTICLE VII.

Having given the angle $a b d$, fig. 7, and the distance from b to a or d , at one of which we wish to commence a curve, it is required to find what radius $a c$ or $c d$ the curve must have, in order to unite with $b a$ and $b d$ tangentially at a and d .

Rule.—Subtract the angle $a b c$, which is half the angle $a b d$, from 90° ; the remainder will be the angle $b c a$ or $b c d$. Then as nat. sine of $b c a$,* is to nat. sine of $a b c$,† so is $a b$ to $a c$, the radius required.

Example.—Let the angle $a b d$ be 120° , and the distance $b a$ or $b d$

* The angle opposite the given side, $a b$.

† The angle opposite the required side, $a c$.

1654 feet; what will be the radius ac or cd of a circle that shall touch a and d tangentially?

Here, the angle abc = half the angle abd , is 60° , which, taken from 90° , leaves the angle bca or $bcd = 30^\circ$. Then as the nat. sine of bca (30°) = .5000 is to nat. sine of abc (60°) = .8660, so is ba (1654 feet) to ac (2865 feet), the radius required.

ARTICLE VIII.

Having given the radius ac , fig. 7, of a curve, and the angle abd , it is required to find the number of chords of 100 feet that will constitute the curve.

Rule.—Subtract the angle abd from 180° , and divide the remainder by the angle of curvature, or deflection of the curve. The quotient will be the required number of chords.

Example.—Let the angle abd be 120° , and the radius ac 2865 feet.

Here, the angle abd , 120° , subtracted from 180° , leaves a remainder of 60° ; which, divided by 2° , the angle of deflection for a curve of 2865 feet, gives a quotient of 30; which is the required number of chords of 100 feet.

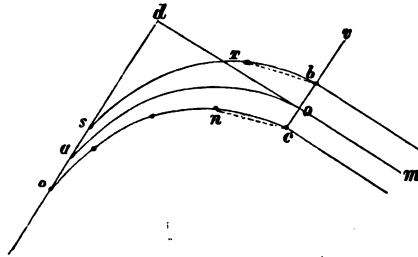
N.B.—Had the quotient contained a *fraction* of a chord, it would have indicated that we should have had to employ a sub-chord at the end of the curve; for instance, had the number of chords been $30\frac{1}{2}$, a sub-chord of 50 feet (very approximately) would have been necessary.

ARTICLE IX.

How to proceed when the end of a curve does not correctly join the tangent.

We sometimes find, in running out a curve for the number of chords determined by the Rule in the preceding Article, that, instead of uniting as it should with the previously determined tangent dm , fig. 8, at o , it

Fig. 8.



ends tangentially to a line *parallel* to said tangent, either *within* it, as at *c*; or *beyond* it, as at *b*. Being first certain that no error has occurred in tracing out the curve, ascertain with the compass the bearing of the tangent *a d*, and, removing the compass to the end of the curve at *c* or *b*, (as the case may be,) run the line *b o* or *c o*, in the same course as *a d*, until it strikes the tangent *d o m*; which may be ascertained by ranging two stakes placed on the tangent.

Then measure *b o* or *c o*, (as the case may be,) and if the curve fall *within* the tangent *o m*, as at *c*, measure *forwards* from *t* towards *d* the distance *t a*, equal to *c o*; or if the curve fall *beyond* the tangent, as at *b*, measure *backwards* from *s* the distance *s a*, equal to *b o*. Then the curve retraced from *a* will terminate tangentially in *d m* at *o*.

N. B.—The direction of *c o* or *b o* may be ascertained without a compass, and better, thus: Multiply the *tangential* angle of the curve by *twice* the number of chords run, *less one*; subtract the product from 180° , and sighting back one chord to *n* or *r*, lay off the angle *n c b* or *r b v*, equal to the remainder. For example, if the tangential angle be 10° , and from *t* to *c* be 4 chords, then 7 times 10° taken from 180° leaves the angle *n c b* or *r b v* = 110° . When the product exceeds 180° , it must be subtracted from 360° for the angle *n c b* or *r b v*.*

This case occurs whenever an error has been made in measuring the distance from *d* to *a*. If *d a* be made too short, the curve *s b* is the result; and if too long, the curve *t c*.

If the error is small, it may be divided equally among the chords by measure without retracing the curve with an instrument. This method may be employed with perfect security so long as the error does not exceed 1 foot to every chord of 100 feet; and it will never be so great if moderate care be taken.

Thus, if the curve be 20 chords long, and the error 20 feet, the last stake may be moved 20 feet, the next 19, the next 18, &c., as nearly at right angles to the curve as can be judged by the eye.

The same ordinates that would have been used had the curve been correct, will answer for the one so adjusted, without perceptible difference. For other cases, see Art. X.

ARTICLE X.

Again, it may happen that the error is not caused by a mismeasurement of the distance *a e*, figs. 9 and 10, as in the last case; but by mistake in obtaining the angle *a e f*.

* In both cases the angle is measured *outwardly* from the curve; but when the curve falls beyond the tangent, as at *b*, then *b v* must be continued inwardly as *b o*.

If aef , fig. 9, be measured in excess, as aeg , then the curve abc ,

Fig. 9.

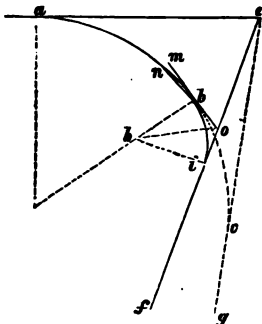
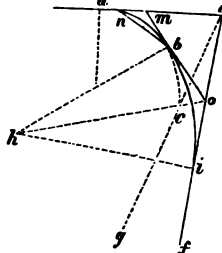


Fig. 10.



calculated for the incorrect angle aeg , will be found to fall *beyond* the true tangent ef , as at c ; and the tangents eg and ef not being parallel, the curve cannot be adjusted by either of the methods given in the preceding Article, unless the error be within about 1 foot to each 100 feet length of curve; in which case, (supposing no other error to exist,) either of those methods may be employed with sufficient accuracy for practice.

Also, if aef , fig. 10, be measured too small, as aeg , then the curve abc , calculated for the incorrect angle aeg , will be found to fall *within* the true tangent ef , as at c ; when so, the remarks contained in the preceding sentence are equally applicable here. If the error be within 1 foot to 100 feet length of curve, it may be equally divided among the chords. But if greater, we must either remeasure the angle aef correctly, and go over the whole work again, or resort to some other mode of obviating the difficulty. The angle aef may be difficult of access; or the curve may be so long that to retrace it would be a work of much labour. We may then adopt the method of *compound curves*, (see Art. XIII.,) by which much trouble will be avoided, and a considerable portion of the first part of the curve be allowed to remain as it is.

Thus, whether the curve abc fall beyond the true tangent ef , as in fig. 9, or inside of it, as in fig. 10, place the instrument at b , figs. 9 and 10, (the point at which the change of radius is to take place,) and sighting back one chord to n , lay off the tangential angle nbm of the curve abc , and observe where the tangent mb continued strikes ef , as at o . Measure both bo , and the angle bof . Half the angle bof taken from 90° gives the angle bho ; then say,

As the $\left\{ \begin{array}{l} \text{Nat. Sine of angle } bho \text{ op-} \\ \text{posite the given side } bo \end{array} \right\}$ is to $\left\{ \begin{array}{l} \text{Nat. Sine of angle } bof \\ \text{opposite the required} \\ \text{side } bh, \end{array} \right\}$ So is The given side bo , to The required side or new radius bh .

Ascertain from the table, or by calculation, the angle of deflection and the tangential angle corresponding to this new radius $b h$; and the new curve commencing at b will terminate tangentially to $e f$ at i , as far from o as o is from b .

For the mode of uniting two curves of different radii, so as to form a *compound curve*, see Article XIII.

It will be observed, that when the first curve $a b c$, fig. 10, falls *inside* the tangent $e f$, the new curve must be of *greater* radius; and when *beyond*, fig. 9, of a *less* one.

ARTICLE XI.

Having given the angles $a b c$ and $b c d$, fig. 11, and the distance $b c$, it is required to find the greatest radius, $g i$ or $h i$, that can be employed in a REVERSE curve, (see Article XIV.) $f o i n m$, for uniting $a b$ to $c d$.

Rule.—Half the angle $a b c$ taken from 90° , leaves the angle $b g i$; and half the angle $b c d$ taken from 90° , leaves the angle $i h c$.

From the table of tangents take the natural tangent ($b i$) of the angle $b g i$; and that ($i c$) of the angle $i h c$; and add them together.

Then as the sum of these two nat.

tangents is to the nat. tang. of $b g i$, so is $b c$ to $b i$; and $b i$ taken from $b c$, gives $i c$.

Again, in the triangle $b g i$, as the nat. sine of the angle $b g i$, opposite the given side $b i$, just found, is to the nat. sine of the angle $g b i$, opposite the required side $g i$, so is $b i$, the given side, to $g i$, the required side or radius.

Example.—Let the angle $a b c$ be $71^\circ 40'$, the angle $b c d$ $129^\circ 15'$, and the distance $b c$ 950 feet. What is the length of radius $h i$ or $g i$, of the easiest reverse curve that can be traced for uniting $a b$ to $c d$?

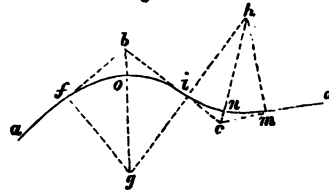
Here, half the angle $a b c$ ($35^\circ 50'$) taken from 90° , leaves the angle $b g i$ $54^\circ 10'$; and half the angle $b c d$ ($64^\circ 37\frac{1}{2}'$) taken from 90° , leaves the angle $i h c$ $25^\circ 22\frac{1}{2}'$.

From the table of tangents, we have nat. tang. of $b g i$ ($54^\circ 10'$) = 1.3848; and nat. tang. of $i h c$ ($25^\circ 22\frac{1}{2}'$) = .4743; their sum being 1.8591.

Then as

Sum of Tang's. } is to { Tang. of } so is { $b c$ } to { $b i$ }
 1.8591 } { $54^\circ 10'$ } { 950 feet, } { 707.63 feet, }

and $b i$, 707.63 feet, taken from $b c$, 950 feet, leaves $i c$ 242.37 feet.



Again, as the

$$\left. \begin{array}{l} \text{Nat. Sine of} \\ \text{angle } b g i \\ \cdot 8107 \end{array} \right\} \text{ is to } \left\{ \begin{array}{l} \text{Nat. Sine of} \\ \text{angle } g b i \\ \cdot 5854, \end{array} \right\} \text{ so is } \left\{ \begin{array}{l} b i \\ 707 \cdot 63 \\ \text{feet} \end{array} \right\} \text{ to } \left\{ \begin{array}{l} g i \text{ or } h i, \text{ the} \\ \text{required radius,} \\ 510 \cdot 97 \text{ feet.} \end{array} \right\}$$

ARTICLE XII.

To obtain the angle $d b e$, formed by two tangents, $d b$ and $b e$, when the point b is inaccessible. Figs. 12, 13, 14, and 15.

This is of frequent occurrence.

CASE 1. When the included figure, fig. 12, has but *three* sides.

Rule.—Subtract the angle $a d e$ from 180° for the angle $b d e$; and subtract the angle $d e c$ from 180° for the angle $d e b$. Add together $b d e$ and $d e b$, and subtract their sum from 180° for the angle $d b e$.



CASE 2. When the included figure, $d b e f$, figs. 13 and 14, has *four* sides.

Rule.—Subtract the sum of the three *internal* angles of the figure marked by dotted segments of circle, from 360° , for the angle $d b e$.

CASE 3. When the included figure, 15, has *more than four* sides.

Rule.—Add together all the *internal* angles, marked by dotted segments of circles; and subtract their sum from twice as many right angles as the figure has sides, less four, for the angle $d b e$.

Example.—Let the angles denoted by the dotted segments at the different letters be as follows: That at d , 70° ; at o , 220° ; at i , 150° ; at s , 110° ; at c , 160° ; at e , 100° . The sum of these is 810° . The figure has 7 sides; and twice 7 less 4 = 10; and 10 right angles = 900° ; from which the sum of the designated internal angles (810°) being subtracted, leaves 90° , for the angle $d b e$.

N.B.—When the angle $d b e$ has to be deduced from a figure of many sides, as fig. 15, the errors spoken of in Articles IX. and X. are apt to occur, unless the several sides and the angles $o i s$, &c., be measured with much care. For tracing curves with any accuracy and satisfaction, the instrument should be divided at least into minutes; as before remarked, the transit instrument is the best for the purpose. With moderate care in the preparatory measurement of the sides and

angles, errors will seldom occur that may not be adjusted with all the accuracy required in practice, by the very simple method of dividing them equally among the chords, as explained in Articles IX. and X.

ARTICLE XIII.

To pass from one curve, a m b, fig. 16, to another, b n c, of different radius, but running in the same direction, constituting a COMPOUND curve.

Rule.—Placing the instrument at *b*, sight back to the other end of the 100 feet chord at *a*; and lay off the tangential angle *a b d*, of the curve *a m b*; then from the common tangent *d b e* lay off the tangential angle *e b c*, of the curve *b n c*, making at the same time the chord *b c*, equal to 100 feet.

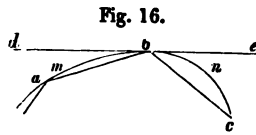


Fig. 16.

N.B.—If running the curve by eye, use the tangential *distances* instead of the angles.

ARTICLE XIV.

To pass from one curve, m n t, fig. 17, to another, t i o, of either the same or of a different radius, but running in an opposite direction, constituting a REVERSE curve.

Rule.—Placing the instrument at *t*, sight back to the other end of the 100 feet chord at *m*, and lay off the tangential angle *m t r*, of the curve *m n t*; then from the common tangent *r t s* lay off the tangential angle *s t o*, of the curve *t i o*, making at the same time the chord *t o*, equal to 100 feet.

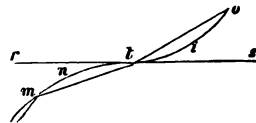


Fig. 17.

N.B.—If running the curve by eye, use the tangential *distances* instead of the angles.

ARTICLE XV.

RADII.

To find the radius corresponding to any given angle of deflection, and to equal chords of any given length.

Rule 1.—Subtract the angle of deflection from 180° , then say, As nat. sine of angle of deflection is to nat. sine of *half* the remainder, so is the given chord to the radius required.

Example.—Let the angle of deflection be 2° , and the chord 100 feet; required the radius.

Here, 2° subtracted from 180° leaves 178° , the half of which is 89° , and as

| | | | | | | |
|------------------------|---|-------------------------|----|----------|---|------------|
| Nat. Sine of 2° | : | Nat. Sine of 89° | :: | Chord | : | Radius |
| .034899 | : | .999848 | :: | 100 feet | : | 2865 feet. |

Rule 2.—The radius for 100 feet chords may be found *approximately*, by dividing 5730 by the deflection angle. This rule is very close for radii of not less than 500 feet. For 500 feet it gives eight-tenths of a foot too little, but is more approximate for larger radii.

Example.—What is the radius to a deflection angle of 2° , the chords being 100 feet long?

Here, 5730 divided by 2 gives 2865 feet, the radius required.

ARTICLE XVI.

TANGENTIAL AND DEFLECTION ANGLES.

To find either the Tangential or Deflection Angle corresponding to any given radius, and to equal chords of any given length.

Rule 1.—Divide *half* the chord by the radius; the quotient will be the natural sine of the *tangential* angle. Therefore the angle corresponding to this sine, in the Table of Natural Sines, will be the tangential angle required; and the tangential angle multiplied by 2 will give the deflection angle.

Example.—Let the radius be 2865 feet, and the chord 100 feet; what will be the tangential and deflection angles?

Here, half the chord (50 feet), divided by the radius (2865 feet), gives .01745; and the tangential angle in the Table corresponding to the natural sine .01745 is 1° , twice which is 2° , the deflection angle required.

Rule 2.—The deflection angle for 100 feet chords may be found approximately by dividing 5730 by the radius. This is very close for curves of over 500 feet radius. For 500 feet it gives about one minute too little.

Example.—What is the deflection angle for a radius of 2865 feet, the chords being 100 each?

Here, 5730 divided by the radius 2865 gives 2° , the deflection angle required.

ARTICLE XVII.

DEFLECTION DISTANCES.

To find the Deflection Distance (exactly) for any given radius, when the chords are 100 feet long.

Rule.—Divide the constant number 10000 by the radius in feet; the quotient will be the deflection angle required.*

Example.—What is the deflection distance to a radius of 5730 feet, the chords being 100 feet long?

Here, 10000 divided by 5730 radius gives 1.745 foot, the deflection distance required.

To find the Deflection Distance for any given radius, and for equal chords of any given length.

Rule.—Divide half the given chord by radius, the quotient will be the natural sine of one-half the deflection angle; and *double* this natural sine, multiplied by the chord, will give the deflection distance required. By this rule our Table was prepared.

Example.—As before, what is the deflection distance to a radius of 5730 feet, the chords being 100 feet long?

Here, half the chord (50 feet), divided by radius (5730 feet), gives .008727, which is the natural sine of half the deflection angle. Now .008727, multiplied by 2, gives .017454, which, multiplied by the chord (100 feet), gives 1.745 foot, the required deflection distance, the same as in the preceding example.

ARTICLE XVIII.

TANGENTIAL DISTANCES.

To find the Tangential Distance corresponding to any given radius, and to equal chords of any given length.

Rule.—First find the tangential angle by Article XVI., and take from the Table of Natural Sines that corresponding to one-half of the *tangential* angle. Then multiply *double* this sine by the given chord, for the tangential distance. By this rule our Table was prepared.

Example.—Let the radius be 2865 feet, and the chords 100 feet each; what will be the tangential distance?

* Because the deflection distance to a radius of 10000 feet, with chords of 100 feet, is 1 foot; and the deflection distances for other radii increase *inversely* as the radii.

Here we find, by Article XVI., the tangential angle 1° for a radius of 2865 feet.

The natural sine corresponding to 30 minutes, or one-half of this tangential angle, is, by the Table of Sines, .008727; the double of which is .017454, which, multiplied by the chord, or 100 feet, gives 1.745 foot for the tangential distance required.

ARTICLE XIX.

ORDINATES.

To find the Middle Ordinate to any given radius, and to any given chord.

Rule 1.—From the square of the radius subtract the square of *half* the chord; and take the square root of the remainder from the radius, for the middle ordinate.

Example.—What is the length of the middle ordinate *d e*, fig. 18, the radius *c a* being 819 feet, and the chord *a b* 100 feet?

Here, the square of *c a* (819) is 670761, and the square of *a e* (50) is 2500; which, being subtracted from the former, leaves 668261; the square root of which is *e c*, 817.472; which, taken from the radius 819, leaves 1.528 foot, the required middle ordinate, *d e*.

Rule 2.—Subtract the tabular cosine of the *tangential* angle from 1, and multiply the remainder by the radius.

Example.—Same as foregoing; namely, radius 819 feet, angle of deflection 7° , to chords of 100 feet. What will be the length of the middle ordinate?

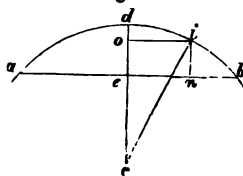
Here, tabular cosine of $3\frac{1}{2}^\circ$ (the tangential angle) is .998135; which, subtracted from 1, leaves .001865; which, multiplied by 819, the radius, gives 1.527, the middle ordinate required.

ARTICLE XX.

*Having given the Middle Ordinate *d e*, fig. 18, it is required to find any other one, as *i n*.*

Rule 1.—Subtract the middle ordinate *d e* from the radius *d c*, the remainder will be *e c*: then from the square of the radius *c i* subtract the square of the distance *o i*, which the required ordinate *i n* is from the middle ordinate *d e*, and extract the square root of the remainder. This square root will be *o c*. From this square root *o c* subtract *e c*; the remainder will be *o e*, which is equal to *i n*, the required ordinate.

Fig. 18.



Example.—The middle ordinate $d e$, of a 100 feet chord $b a$, to a radius of 819, being 1.528 foot, it is required to find the length of the ordinate $i n$, 20 feet from the middle one.

Here, the middle ordinate $d e$, 1.528, subtracted from the radius 819, leaves $e c$, 817.472. The square of the radius is 670761; and the square of 20 (the distance of the required ordinate from the middle one) is 400; which, taken from 670761, leaves 670361; the square root of which is 818.756, or $o c$; from which take $e c$, or 817.472, and the remainder, 1.284, will be $o e$, which is equal to $i n$, the required ordinate.

Rule 2.—Multiply the ordinates of a 1° curve by the deflection angle of the curve whose ordinates are required (chords being 100 feet). This is a sufficiently close approximation for curves of not less than 500 feet radius; and for placing ordinates *for guiding the excavations and embankments*, it is close enough for the smallest curves in our Table.

I.—TABLE OF RADII, &c.—Chord 100 feet.

The Tangential Angle is always one-half of the Angle of Deflection.

| Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. | Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. |
|----------------------|-----------------|------------------------------|------------------------------|----------------------|-----------------|------------------------------|------------------------------|
| 1 | 343800 | ·029 | ·014 | 51 | 6741 | 1·482 | ·741 |
| 2 | 171900 | ·058 | ·029 | 52 | 6611 | 1·511 | ·755 |
| 3 | 114600 | ·087 | ·043 | 53 | 6487 | 1·540 | ·770 |
| 4 | 85950 | ·116 | ·058 | 54 | 6367 | 1·569 | ·784 |
| 5 | 68760 | ·145 | ·072 | 55 | 6251 | 1·598 | ·799 |
| 6 | 57300 | ·174 | ·087 | 56 | 6139 | 1·627 | ·813 |
| 7 | 49116 | ·203 | ·101 | 57 | 6032 | 1·656 | ·828 |
| 8 | 42975 | ·232 | ·116 | 58 | 5928 | 1·685 | ·842 |
| 9 | 38200 | ·262 | ·131 | 59 | 5827 | 1·715 | ·857 |
| 10 | 34380 | ·291 | ·145 | 1 | 5730 | 1·745 | ·872 |
| 11 | 31256 | ·320 | ·160 | 2 | 5545 | 1·802 | ·901 |
| 12 | 28650 | ·349 | ·174 | 4 | 5372 | 1·860 | ·930 |
| 13 | 26446 | ·378 | ·189 | 6 | 5209 | 1·918 | ·959 |
| 14 | 24558 | ·407 | ·203 | 8 | 5056 | 1·976 | ·988 |
| 15 | 22920 | ·436 | ·218 | 10 | 4912 | 2·036 | 1·018 |
| 16 | 21487 | ·465 | ·232 | 12 | 4775 | 2·094 | 1·047 |
| 17 | 20224 | ·494 | ·247 | 14 | 4646 | 2·152 | 1·076 |
| 18 | 19100 | ·523 | ·261 | 16 | 4524 | 2·210 | 1·105 |
| 19 | 18094 | ·552 | ·276 | 18 | 4408 | 2·268 | 1·134 |
| 20 | 17190 | ·581 | ·290 | 20 | 4298 | 2·326 | 1·163 |
| 21 | 16372 | ·610 | ·305 | 22 | 4193 | 2·384 | 1·192 |
| 22 | 15628 | ·639 | ·319 | 24 | 4093 | 2·443 | 1·221 |
| 23 | 14948 | ·668 | ·334 | 26 | 3998 | 2·501 | 1·250 |
| 24 | 14325 | ·697 | ·348 | 28 | 3907 | 2·559 | 1·279 |
| 25 | 13752 | ·727 | ·363 | 30 | 3820 | 2·617 | 1·308 |
| 26 | 13223 | ·756 | ·378 | 32 | 3737 | 2·676 | 1·338 |
| 27 | 12733 | ·785 | ·392 | 34 | 3657 | 2·734 | 1·367 |
| 28 | 12279 | ·814 | ·407 | 36 | 3581 | 2·793 | 1·396 |
| 29 | 11856 | ·843 | ·421 | 38 | 3508 | 2·851 | 1·425 |
| 30 | 11460 | ·872 | ·436 | 40 | 3438 | 2·908 | 1·454 |
| 31 | 11090 | ·900 | ·450 | 42 | 3370 | 2·967 | 1·483 |
| 32 | 10744 | ·930 | ·465 | 44 | 3306 | 3·025 | 1·512 |
| 33 | 10419 | ·959 | ·479 | 46 | 3243 | 3·083 | 1·541 |
| 34 | 10112 | ·988 | ·494 | 48 | 3183 | 3·141 | 1·570 |
| 35 | 9823 | 1·017 | ·508 | 50 | 3126 | 3·199 | 1·599 |
| 36 | 9550 | 1·046 | ·523 | 52 | 3069 | 3·258 | 1·629 |
| 37 | 9292 | 1·075 | ·537 | 54 | 3016 | 3·316 | 1·658 |
| 38 | 9047 | 1·104 | ·552 | 56 | 2964 | 3·374 | 1·687 |
| 39 | 8815 | 1·133 | ·566 | 58 | 2914 | 3·432 | 1·716 |
| 40 | 8595 | 1·162 | ·581 | 2 | 2865 | 3·490 | 1·745 |
| 41 | 8385 | 1·191 | ·595 | 4 | 2818 | 3·548 | 1·774 |
| 42 | 8186 | 1·221 | ·610 | 6 | 2772 | 3·606 | 1·803 |
| 43 | 7995 | 1·250 | ·625 | 8 | 2729 | 3·665 | 1·832 |
| 44 | 7814 | 1·279 | ·639 | 10 | 2686 | 3·723 | 1·861 |
| 45 | 7640 | 1·308 | ·654 | 12 | 2644 | 3·781 | 1·890 |
| 46 | 7474 | 1·337 | ·668 | 14 | 2604 | 3·839 | 1·919 |
| 47 | 7315 | 1·366 | ·683 | 16 | 2566 | 3·897 | 1·948 |
| 48 | 7162 | 1·395 | ·697 | 18 | 2528 | 3·956 | 1·978 |
| 49 | 7016 | 1·424 | ·712 | 20 | 2491 | 4·014 | 2·007 |
| 50 | 6876 | 1·453 | ·726 | | 2456 | 4·072 | 2·036 |

I.—TABLE OF RADII, &c.—continued.

| Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. | Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. |
|----------------------|-----------------|------------------------------|------------------------------|----------------------|-----------------|------------------------------|------------------------------|
| 2 22 | 2421 | 4'130 | 2'065 | 4 15 | 1348 | 7'416 | 3'708 |
| 24 | 2387 | 4'188 | 2'094 | 20 | 1322 | 7'563 | 3'781 |
| 26 | 2355 | 4'246 | 2'123 | 25 | 1298 | 7'708 | 3'854 |
| 28 | 2323 | 4'305 | 2'152 | 30 | 1274 | 7'853 | 3'927 |
| 30 | 2292 | 4'363 | 2'182 | 35 | 1251 | 7'998 | 3'999 |
| 32 | 2262 | 4'421 | 2'210 | 40 | 1228 | 8'143 | 4'071 |
| 34 | 2232 | 4'479 | 2'239 | 45 | 1207 | 8'289 | 4'145 |
| 36 | 2204 | 4'538 | 2'269 | 50 | 1185 | 8'432 | 4'216 |
| 38 | 2176 | 4'596 | 2'298 | 55 | 1166 | 8'577 | 4'288 |
| 40 | 2149 | 4'653 | 2'326 | 5 | 1146 | 8'722 | 4'361 |
| 42 | 2122 | 4'712 | 2'356 | 5 | 1127 | 8'869 | 4'434 |
| 44 | 2096 | 4'770 | 2'385 | 10 | 1109 | 9'014 | 4'507 |
| 46 | 2071 | 4'828 | 2'414 | 15 | 1092 | 9'159 | 4'579 |
| 48 | 2046 | 4'886 | 2'443 | 20 | 1074 | 9'304 | 4'652 |
| 50 | 2023 | 4'944 | 2'472 | 25 | 1058 | 9'449 | 4'724 |
| 52 | 1999 | 5'002 | 2'501 | 30 | 1042 | 9'595 | 4'798 |
| 54 | 1976 | 5'060 | 2'530 | 35 | 1026 | 9'740 | 4'870 |
| 56 | 1953 | 5'118 | 2'559 | 40 | 1011 | 9'885 | 4'942 |
| 58 | 1932 | 5'176 | 2'588 | 45 | 996'8 | 10'03 | 5'015 |
| 3 | 1910 | 5'235 | 2'618 | 50 | 982'7 | 10'18 | 5'090 |
| 2 | 1889 | 5'293 | 2'646 | 55 | 969'0 | 10'32 | 5'160 |
| 4 | 1868 | 5'351 | 2'675 | 6 | 955'4 | 10'47 | 5'235 |
| 6 | 1848 | 5'409 | 2'704 | 5 | 947'5 | 10'62 | 5'310 |
| 8 | 1828 | 5'468 | 2'734 | 10 | 939'7 | 10'76 | 5'380 |
| 10 | 1810 | 5'526 | 2'763 | 15 | 917'0 | 10'90 | 5'450 |
| 12 | 1790 | 5'584 | 2'792 | 20 | 905'0 | 11'04 | 5'520 |
| 14 | 1772 | 5'642 | 2'821 | 25 | 893'5 | 11'20 | 5'600 |
| 16 | 1754 | 5'700 | 2'850 | 30 | 882'0 | 11'34 | 5'670 |
| 18 | 1736 | 5'758 | 2'879 | 35 | 870'7 | 11'48 | 5'740 |
| 20 | 1719 | 5'817 | 2'908 | 40 | 859'5 | 11'63 | 5'815 |
| 22 | 1702 | 5'875 | 2'937 | 45 | 849'3 | 11'78 | 5'890 |
| 24 | 1685 | 5'933 | 2'966 | 50 | 838'9 | 11'92 | 5'960 |
| 26 | 1669 | 5'992 | 2'996 | 55 | 828'9 | 12'06 | 6'030 |
| 28 | 1653 | 6'050 | 3'025 | 7 | 819'0 | 12'21 | 6'105 |
| 30 | 1637 | 6'108 | 3'054 | 5 | 813'3 | 12'36 | 6'180 |
| 32 | 1621 | 6'166 | 3'083 | 10 | 807'4 | 12'50 | 6'250 |
| 34 | 1606 | 6'224 | 3'112 | 15 | 790'8 | 12'64 | 6'320 |
| 36 | 1591 | 6'282 | 3'141 | 20 | 781'9 | 12'79 | 6'395 |
| 38 | 1577 | 6'340 | 3'170 | 25 | 773'2 | 12'94 | 6'470 |
| 40 | 1563 | 6'398 | 3'199 | 30 | 764'5 | 13'08 | 6'540 |
| 42 | 1549 | 6'456 | 3'228 | 35 | 756'1 | 13'22 | 6'610 |
| 44 | 1534 | 6'515 | 3'257 | 40 | 748'0 | 13'37 | 6'685 |
| 46 | 1521 | 6'574 | 3'287 | 45 | 739'9 | 13'51 | 6'755 |
| 48 | 1508 | 6'632 | 3'316 | 50 | 732'0 | 13'66 | 6'830 |
| 50 | 1495 | 6'690 | 3'345 | 55 | 724'3 | 13'80 | 6'900 |
| 52 | 1482 | 6'748 | 3'374 | 8 | 716'8 | 13'95 | 6'975 |
| 54 | 1469 | 6'806 | 3'403 | 15 | 695'1 | 14'38 | 7'190 |
| 56 | 1457 | 6'864 | 3'432 | 30 | 674'6 | 14'81 | 7'405 |
| 58 | 1445 | 6'922 | 3'461 | 45 | 655'5 | 15'25 | 7'625 |
| 4 | 1433 | 6'980 | 3'490 | 9 | 637'3 | 15'68 | 7'840 |
| 5 | 1403 | 7'125 | 3'562 | 15 | 620'2 | 16'12 | 8'060 |
| 10 | 1375 | 7'270 | 3'635 | 30 | 603'8 | 16'55 | 8'275 |

I.—TABLE OF RADII, &c.—*continued.*

| Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. | Angle of Deflection. | Radius in feet. | Deflection distance in feet. | Tangential distance in feet. |
|----------------------|-----------------|------------------------------|------------------------------|----------------------|-----------------|------------------------------|------------------------------|
| 9 45 | 588.4 | 16.99 | 8.495 | 17 0 | 338.3 | 29.56 | 14.82 |
| 10 15 | 573.7 | 17.43 | 8.715 | 17 30 | 328.7 | 30.43 | 15.25 |
| 10 30 | 559.7 | 17.87 | 8.935 | 18 0 | 319.6 | 21.29 | 15.69 |
| 10 45 | 546.4 | 18.30 | 9.150 | 18 30 | 311.0 | 32.15 | 16.12 |
| 11 15 | 533.8 | 18.73 | 9.365 | 19 0 | 302.9 | 33.01 | 16.56 |
| 11 30 | 521.7 | 19.17 | 9.585 | 19 30 | 295.3 | 33.87 | 16.99 |
| 11 45 | 510.1 | 19.61 | 9.805 | 20 0 | 287.9 | 34.73 | 17.43 |
| 12 15 | 499.1 | 20.05 | 10.03 | 21 0 | 274.4 | 36.44 | 18.30 |
| 12 30 | 488.5 | 20.50 | 10.25 | 22 0 | 262.0 | 38.15 | 19.17 |
| 12 45 | 478.3 | 20.94 | 10.47 | 23 0 | 250.8 | 39.87 | 20.02 |
| 13 15 | 468.7 | 21.36 | 10.69 | 24 0 | 240.5 | 41.58 | 20.91 |
| 13 30 | 459.3 | 21.79 | 10.90 | 25 0 | 231.0 | 43.28 | 21.77 |
| 13 45 | 450.3 | 22.21 | 11.12 | 26 0 | 222.3 | 44.98 | 22.64 |
| 14 15 | 441.7 | 22.64 | 11.34 | 27 0 | 214.2 | 46.68 | 23.51 |
| 14 30 | 433.4 | 23.07 | 11.56 | 28 0 | 206.7 | 48.38 | 24.37 |
| 14 45 | 425.5 | 23.51 | 11.77 | 29 0 | 199.7 | 50.07 | 25.24 |
| 15 15 | 417.7 | 23.94 | 11.99 | 30 0 | 193.2 | 51.76 | 26.11 |
| 15 30 | 410.3 | 24.37 | 12.21 | 31 0 | 187.1 | 53.45 | 26.97 |
| 15 45 | 403.1 | 24.81 | 12.43 | 32 0 | 181.4 | 55.13 | 27.83 |
| 16 15 | 396.2 | 25.24 | 12.65 | 33 0 | 176.0 | 56.80 | 28.70 |
| 16 30 | 389.6 | 25.67 | 12.86 | 34 0 | 171.0 | 58.47 | 29.56 |
| 16 45 | 383.1 | 26.11 | 13.08 | 35 0 | 166.3 | 60.14 | 30.42 |
| 17 15 | 376.9 | 26.52 | 13.30 | 36 0 | 161.8 | 61.80 | 31.29 |
| 17 30 | 370.8 | 26.94 | 13.52 | 37 0 | 157.6 | 63.46 | 32.15 |
| 17 45 | 365.0 | 27.37 | 13.73 | 38 0 | 153.6 | 65.11 | 33.01 |
| 18 15 | 359.3 | 27.83 | 13.95 | 39 0 | 149.8 | 66.76 | 33.87 |
| 18 30 | 348.4 | 28.70 | 14.38 | 40 0 | 146.2 | 68.40 | 34.73 |

II.—TABLE OF ORDINATES.

Ordinates five feet apart.—Chord 100 feet.

| Distances of the Ordinates from the end of the 100 feet Chord. | | | | | | | | | | |
|--|------------------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Angle of Deflection. | Middle, 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| 0 2 | .007 | .007 | .007 | .006 | .006 | .005 | .003 | .003 | .002 | .001 |
| 4 | .014 | .014 | .014 | .013 | .012 | .010 | .008 | .008 | .005 | .003 |
| 6 | .021 | .021 | .021 | .020 | .019 | .016 | .013 | .011 | .008 | .004 |
| 8 | .029 | .029 | .028 | .026 | .024 | .022 | .018 | .015 | .010 | .005 |
| 10 | .036 | .036 | .035 | .033 | .031 | .027 | .023 | .019 | .013 | .007 |
| 12 | .043 | .043 | .041 | .038 | .037 | .033 | .028 | .022 | .015 | .008 |
| 14 | .050 | .050 | .048 | .044 | .043 | .038 | .032 | .026 | .017 | .010 |
| 16 | .058 | .058 | .056 | .052 | .049 | .044 | .037 | .030 | .020 | .011 |
| 18 | .065 | .065 | .063 | .059 | .055 | .050 | .042 | .033 | .023 | .013 |
| 20 | .073 | .072 | .070 | .066 | .061 | .055 | .047 | .037 | .026 | .014 |
| 22 | .080 | .079 | .076 | .071 | .067 | .060 | .051 | .041 | .029 | .015 |

II.—TABLE OF ORDINATES—*continued.*

| Distances of the Ordinates from the end of the 100 feet Chord. | | | | | | | | | | |
|--|---------------------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Angle of De- fection. | Middle, 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| ° 24 | ·087 | ·086 | ·083 | ·077 | ·074 | ·066 | ·056 | ·045 | ·031 | ·017 |
| 26 | ·094 | ·093 | ·090 | ·084 | ·080 | ·071 | ·060 | ·048 | ·034 | ·018 |
| 28 | ·102 | ·101 | ·098 | ·092 | ·086 | ·077 | ·065 | ·052 | ·036 | ·019 |
| 30 | ·109 | ·108 | ·105 | ·099 | ·092 | ·082 | ·070 | ·055 | ·039 | ·020 |
| 32 | ·116 | ·115 | ·112 | ·106 | ·098 | ·088 | ·075 | ·058 | ·042 | ·022 |
| 34 | ·123 | ·122 | ·118 | ·111 | ·104 | ·094 | ·079 | ·062 | ·044 | ·023 |
| 36 | ·131 | ·130 | ·126 | ·119 | ·110 | ·099 | ·084 | ·066 | ·047 | ·024 |
| 38 | ·138 | ·137 | ·133 | ·126 | ·116 | ·105 | ·089 | ·070 | ·049 | ·025 |
| 40 | ·145 | ·144 | ·140 | ·133 | ·123 | ·110 | ·093 | ·074 | ·052 | ·027 |
| 42 | ·152 | ·150 | ·146 | ·138 | ·128 | ·115 | ·098 | ·077 | ·055 | ·028 |
| 44 | ·160 | ·158 | ·153 | ·145 | ·135 | ·121 | ·103 | ·081 | ·057 | ·030 |
| 46 | ·167 | ·165 | ·160 | ·152 | ·141 | ·126 | ·107 | ·085 | ·060 | ·032 |
| 48 | ·174 | ·172 | ·167 | ·158 | ·147 | ·132 | ·112 | ·088 | ·062 | ·033 |
| 50 | ·182 | ·180 | ·175 | ·166 | ·153 | ·138 | ·117 | ·092 | ·065 | ·034 |
| 52 | ·189 | ·187 | ·181 | ·171 | ·159 | ·143 | ·122 | ·095 | ·068 | ·035 |
| 54 | ·196 | ·194 | ·188 | ·178 | ·165 | ·148 | ·126 | ·099 | ·070 | ·036 |
| 56 | ·204 | ·202 | ·195 | ·185 | ·171 | ·154 | ·131 | ·103 | ·073 | ·038 |
| 58 | ·211 | ·209 | ·202 | ·192 | ·177 | ·159 | ·136 | ·107 | ·075 | ·039 |
| 1 2 | ·218 | ·216 | ·209 | ·198 | ·183 | ·164 | ·140 | ·111 | ·078 | ·041 |
| 4 | ·225 | ·223 | ·215 | ·204 | ·189 | ·169 | ·145 | ·114 | ·081 | ·042 |
| 6 | ·233 | ·231 | ·223 | ·211 | ·196 | ·175 | ·150 | ·118 | ·083 | ·043 |
| 8 | ·240 | ·238 | ·230 | ·217 | ·202 | ·180 | ·155 | ·121 | ·086 | ·045 |
| 10 | ·247 | ·245 | ·237 | ·224 | ·208 | ·186 | ·159 | ·125 | ·088 | ·046 |
| 12 | ·254 | ·252 | ·244 | ·231 | ·214 | ·191 | ·163 | ·130 | ·091 | ·048 |
| 14 | ·262 | ·260 | ·252 | ·237 | ·220 | ·196 | ·168 | ·133 | ·094 | ·049 |
| 16 | ·269 | ·267 | ·258 | ·244 | ·226 | ·202 | ·173 | ·136 | ·096 | ·050 |
| 18 | ·276 | ·274 | ·265 | ·251 | ·232 | ·207 | ·177 | ·140 | ·099 | ·052 |
| 20 | ·284 | ·282 | ·273 | ·257 | ·238 | ·213 | ·182 | ·144 | ·101 | ·053 |
| 22 | ·291 | ·288 | ·279 | ·264 | ·244 | ·218 | ·187 | ·148 | ·104 | ·055 |
| 24 | ·298 | ·295 | ·285 | ·270 | ·250 | ·224 | ·192 | ·151 | ·107 | ·056 |
| 26 | ·306 | ·303 | ·293 | ·277 | ·256 | ·229 | ·197 | ·155 | ·109 | ·057 |
| 28 | ·313 | ·310 | ·300 | ·284 | ·263 | ·235 | ·201 | ·159 | ·112 | ·059 |
| 30 | ·320 | ·317 | ·307 | ·291 | ·269 | ·240 | ·206 | ·163 | ·114 | ·060 |
| 32 | ·327 | ·324 | ·314 | ·297 | ·275 | ·246 | ·210 | ·167 | ·117 | ·062 |
| 34 | ·334 | ·331 | ·321 | ·304 | ·281 | ·251 | ·215 | ·171 | ·120 | ·063 |
| 36 | ·341 | ·338 | ·328 | ·310 | ·287 | ·257 | ·219 | ·174 | ·122 | ·065 |
| 38 | ·349 | ·345 | ·335 | ·317 | ·293 | ·262 | ·224 | ·178 | ·125 | ·066 |
| 40 | ·356 | ·353 | ·342 | ·323 | ·299 | ·268 | ·228 | ·182 | ·127 | ·068 |
| 42 | ·364 | ·360 | ·349 | ·330 | ·305 | ·273 | ·233 | ·185 | ·130 | ·069 |
| 44 | ·371 | ·367 | ·356 | ·337 | ·312 | ·278 | ·238 | ·189 | ·133 | ·070 |
| 46 | ·378 | ·374 | ·363 | ·343 | ·318 | ·284 | ·242 | ·192 | ·135 | ·072 |
| 48 | ·385 | ·382 | ·370 | ·350 | ·324 | ·289 | ·247 | ·196 | ·138 | ·073 |
| 50 | ·393 | ·389 | ·377 | ·356 | ·330 | ·295 | ·251 | ·200 | ·141 | ·075 |
| 52 | ·400 | ·396 | ·384 | ·364 | ·336 | ·300 | ·256 | ·204 | ·144 | ·076 |
| 54 | ·407 | ·403 | ·391 | ·370 | ·342 | ·305 | ·261 | ·208 | ·147 | ·077 |
| 56 | ·414 | ·410 | ·398 | ·376 | ·348 | ·311 | ·265 | ·211 | ·149 | ·079 |
| 58 | ·422 | ·418 | ·405 | ·383 | ·354 | ·316 | ·270 | ·215 | ·152 | ·080 |
| 2 2 | ·429 | ·425 | ·412 | ·389 | ·360 | ·322 | ·275 | ·219 | ·154 | ·082 |
| 4 | ·436 | ·432 | ·419 | ·397 | ·366 | ·327 | ·280 | ·222 | ·157 | ·083 |
| | ·443 | ·439 | ·426 | ·402 | ·373 | ·332 | ·284 | ·226 | ·160 | ·084 |
| | ·451 | ·446 | ·433 | ·409 | ·379 | ·338 | ·289 | ·230 | ·162 | ·086 |

II.—TABLE OF ORDINATES—*continued.*

| Distances of the Ordinates from the end of the 100 feet Chord. | | | | | | | | | | |
|--|------------------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Angle of Deflection. | Middle, 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| 2 | 6 | .458 | .454 | .440 | .416 | .385 | .343 | .293 | .234 | .165 |
| 8 | 8 | .465 | .461 | .447 | .425 | .391 | .349 | .298 | .237 | .167 |
| 10 | 10 | .473 | .468 | .454 | .430 | .397 | .355 | .303 | .241 | .170 |
| 12 | 12 | .480 | .475 | .461 | .437 | .403 | .360 | .308 | .245 | .173 |
| 14 | 14 | .487 | .482 | .468 | .443 | .409 | .366 | .312 | .248 | .175 |
| 16 | 16 | .495 | .490 | .475 | .450 | .415 | .371 | .317 | .252 | .178 |
| 18 | 18 | .502 | .497 | .482 | .456 | .421 | .377 | .321 | .256 | .180 |
| 20 | 20 | .509 | .504 | .489 | .463 | .428 | .382 | .326 | .260 | .183 |
| 22 | 22 | .516 | .511 | .496 | .470 | .434 | .387 | .330 | .264 | .186 |
| 24 | 24 | .523 | .518 | .503 | .476 | .440 | .393 | .334 | .267 | .188 |
| 26 | 26 | .531 | .526 | .510 | .483 | .446 | .398 | .338 | .271 | .191 |
| 28 | 28 | .538 | .533 | .517 | .489 | .452 | .404 | .346 | .275 | .194 |
| 30 | 30 | .545 | .540 | .524 | .496 | .458 | .409 | .350 | .278 | .196 |
| 32 | 32 | .552 | .547 | .531 | .503 | .465 | .415 | .355 | .282 | .199 |
| 34 | 34 | .560 | .554 | .538 | .509 | .471 | .420 | .359 | .285 | .201 |
| 36 | 36 | .567 | .562 | .545 | .516 | .477 | .425 | .364 | .289 | .204 |
| 38 | 38 | .574 | .569 | .552 | .522 | .483 | .431 | .368 | .293 | .206 |
| 40 | 40 | .582 | .576 | .559 | .529 | .489 | .436 | .373 | .297 | .209 |
| 42 | 42 | .589 | .583 | .566 | .536 | .495 | .441 | .378 | .301 | .212 |
| 44 | 44 | .596 | .590 | .573 | .542 | .501 | .447 | .382 | .304 | .214 |
| 46 | 46 | .603 | .598 | .580 | .549 | .507 | .452 | .387 | .308 | .217 |
| 48 | 48 | .611 | .605 | .587 | .555 | .513 | .458 | .391 | .312 | .219 |
| 50 | 50 | .618 | .612 | .594 | .562 | .519 | .464 | .396 | .315 | .222 |
| 52 | 52 | .625 | .619 | .601 | .569 | .526 | .469 | .401 | .319 | .225 |
| 54 | 54 | .632 | .626 | .608 | .575 | .532 | .474 | .405 | .322 | .227 |
| 56 | 56 | .640 | .634 | .615 | .582 | .538 | .480 | .410 | .326 | .230 |
| 58 | 58 | .647 | .641 | .622 | .588 | .544 | .485 | .414 | .330 | .232 |
| 3 | | .654 | .648 | .629 | .595 | .550 | .491 | .419 | .334 | .235 |
| 2 | 2 | .661 | .655 | .636 | .602 | .556 | .497 | .424 | .338 | .238 |
| 4 | 4 | .669 | .662 | .643 | .608 | .562 | .502 | .428 | .341 | .240 |
| 6 | 6 | .676 | .670 | .650 | .615 | .568 | .507 | .433 | .345 | .243 |
| 8 | 8 | .683 | .677 | .657 | .621 | .574 | .512 | .438 | .349 | .246 |
| 10 | 10 | .691 | .684 | .664 | .629 | .581 | .518 | .443 | .353 | .249 |
| 12 | 12 | .698 | .691 | .671 | .635 | .587 | .523 | .448 | .357 | .251 |
| 14 | 14 | .706 | .698 | .678 | .642 | .593 | .529 | .452 | .360 | .254 |
| 16 | 16 | .713 | .705 | .685 | .649 | .599 | .534 | .457 | .364 | .257 |
| 18 | 18 | .720 | .713 | .692 | .655 | .605 | .540 | .462 | .368 | .259 |
| 20 | 20 | .727 | .720 | .699 | .662 | .611 | .545 | .466 | .371 | .262 |
| 22 | 22 | .734 | .727 | .706 | .668 | .617 | .550 | .471 | .375 | .264 |
| 24 | 24 | .742 | .734 | .713 | .675 | .623 | .556 | .475 | .378 | .267 |
| 26 | 26 | .749 | .742 | .720 | .682 | .629 | .561 | .480 | .382 | .270 |
| 28 | 28 | .756 | .749 | .727 | .688 | .635 | .567 | .485 | .386 | .272 |
| 30 | 30 | .764 | .756 | .734 | .695 | .642 | .573 | .489 | .390 | .275 |
| 32 | 32 | .771 | .763 | .741 | .702 | .648 | .578 | .494 | .394 | .278 |
| 34 | 34 | .779 | .770 | .748 | .708 | .654 | .584 | .498 | .397 | .280 |
| 36 | 36 | .786 | .777 | .755 | .715 | .660 | .589 | .503 | .401 | .283 |
| 38 | 38 | .793 | .785 | .762 | .721 | .666 | .594 | .508 | .405 | .285 |
| 40 | 40 | .800 | .792 | .769 | .728 | .673 | .600 | .512 | .408 | .288 |
| 42 | 42 | .807 | .799 | .776 | .734 | .679 | .605 | .517 | .412 | .291 |
| 44 | 44 | .814 | .806 | .783 | .741 | .685 | .611 | .521 | .415 | .293 |
| 46 | 46 | .822 | .814 | .790 | .748 | .691 | .616 | .526 | .419 | .296 |

II.—TABLE OF ORDINATES—continued.

| Distances of the Ordinates from the end of the 100 feet Chord. | | | | | | | | | | |
|--|------------------|----------|----------|----------|----------|----------|----------|----------|----------|---------|
| Angle of Deflection. | Middle, 50 feet. | 45 feet. | 40 feet. | 35 feet. | 30 feet. | 25 feet. | 20 feet. | 15 feet. | 10 feet. | 5 feet. |
| 0 | | | | | | | | | | |
| 3 48 | .829 | .821 | .797 | .754 | .697 | .621 | .531 | .423 | .298 | .158 |
| 50 | .836 | .828 | .804 | .761 | .703 | .627 | .536 | .427 | .301 | .159 |
| 52 | .843 | .835 | .811 | .768 | .709 | .632 | .541 | .431 | .304 | .160 |
| 54 | .850 | .842 | .818 | .774 | .715 | .638 | .545 | .434 | .306 | .162 |
| 56 | .858 | .850 | .825 | .781 | .721 | .643 | .550 | .438 | .309 | .163 |
| 58 | .865 | .857 | .832 | .787 | .728 | .648 | .555 | .442 | .311 | .165 |
| 4 | .873 | .864 | .839 | .794 | .734 | .655 | .559 | .445 | .314 | .166 |
| 5 | .891 | .882 | .856 | .810 | .749 | .668 | .571 | .454 | .320 | .169 |
| 10 | .909 | .900 | .874 | .827 | .764 | .682 | .582 | .464 | .327 | .173 |
| 15 | .927 | .918 | .891 | .844 | .780 | .695 | .594 | .473 | .334 | .176 |
| 20 | .945 | .936 | .909 | .860 | .795 | .709 | .606 | .482 | .340 | .179 |
| 25 | .963 | .954 | .926 | .877 | .810 | .723 | .617 | .491 | .347 | .183 |
| 30 | .981 | .972 | .944 | .893 | .825 | .736 | .629 | .501 | .354 | .186 |
| 35 | .999 | .990 | .961 | .909 | .840 | .750 | .640 | .510 | .360 | .189 |
| 40 | 1.017 | 1.008 | .979 | .926 | .855 | .764 | .652 | .519 | .367 | .193 |
| 45 | 1.036 | 1.026 | .996 | .943 | .871 | .777 | .664 | .529 | .373 | .196 |
| 50 | 1.054 | 1.044 | 1.014 | .959 | .886 | .791 | .676 | .538 | .380 | .199 |
| 55 | 1.072 | 1.062 | 1.031 | .976 | .901 | .804 | .687 | .547 | .386 | .203 |
| 5 | 1.091 | 1.080 | 1.048 | .993 | .917 | .818 | .699 | .557 | .393 | .207 |
| 5 | 1.109 | 1.098 | 1.065 | 1.009 | .932 | .831 | .711 | .566 | .400 | .210 |
| 10 | 1.127 | 1.116 | 1.083 | 1.026 | .947 | .845 | .722 | .576 | .406 | .214 |
| 15 | 1.146 | 1.134 | 1.000 | 1.042 | .963 | .859 | .734 | .585 | .413 | .217 |
| 20 | 1.164 | 1.152 | 1.118 | 1.058 | .978 | .872 | .746 | .594 | .419 | .220 |
| 25 | 1.182 | 1.170 | 1.135 | 1.075 | .993 | .886 | .757 | .603 | .426 | .224 |
| 30 | 1.200 | 1.188 | 1.153 | 1.092 | 1.009 | .900 | .769 | .613 | .432 | .228 |
| 35 | 1.218 | 1.206 | 1.170 | 1.108 | 1.024 | .913 | .781 | .622 | .438 | .231 |
| 40 | 1.236 | 1.224 | 1.188 | 1.124 | 1.039 | .927 | .792 | .631 | .445 | .235 |
| 45 | 1.255 | 1.242 | 1.205 | 1.141 | 1.055 | .941 | .804 | .640 | .452 | .238 |
| 50 | 1.273 | 1.260 | 1.223 | 1.157 | 1.070 | .954 | .816 | .649 | .458 | .241 |
| 55 | 1.291 | 1.278 | 1.240 | 1.174 | 1.085 | .967 | .827 | .658 | .465 | .245 |
| 6 | 1.309 | 1.296 | 1.258 | 1.191 | 1.100 | .982 | .839 | .668 | .472 | .248 |
| 5 | 1.327 | 1.314 | 1.275 | 1.207 | 1.115 | .995 | .851 | .677 | .478 | .251 |
| 10 | 1.345 | 1.332 | 1.293 | 1.224 | 1.130 | 1.009 | .862 | .686 | .485 | .255 |
| 15 | 1.364 | 1.350 | 1.310 | 1.240 | 1.146 | 1.023 | .874 | .696 | .492 | .259 |
| 20 | 1.382 | 1.368 | 1.328 | 1.256 | 1.161 | 1.036 | .886 | .705 | .498 | .262 |
| 25 | 1.400 | 1.386 | 1.345 | 1.273 | 1.176 | 1.050 | .897 | .714 | .505 | .266 |
| 30 | 1.419 | 1.404 | 1.362 | 1.290 | 1.192 | 1.064 | .909 | .724 | .511 | .269 |
| 35 | 1.437 | 1.422 | 1.379 | 1.306 | 1.207 | 1.077 | .921 | .733 | .517 | .272 |
| 40 | 1.455 | 1.440 | 1.397 | 1.323 | 1.222 | 1.091 | .932 | .742 | .524 | .276 |
| 45 | 1.473 | 1.458 | 1.415 | 1.339 | 1.238 | 1.105 | .944 | .752 | .531 | .280 |
| 50 | 1.491 | 1.476 | 1.432 | 1.355 | 1.253 | 1.118 | .956 | .761 | .537 | .283 |
| 55 | 1.509 | 1.494 | 1.450 | 1.372 | 1.268 | 1.132 | .967 | .770 | .544 | .287 |
| 7 | 1.528 | 1.512 | 1.467 | 1.389 | 1.284 | 1.146 | .979 | .779 | .551 | .290 |
| 5 | 1.546 | 1.530 | 1.484 | 1.405 | 1.299 | 1.159 | .991 | .788 | .557 | .293 |
| 10 | 1.564 | 1.548 | 1.502 | 1.422 | 1.314 | 1.173 | 1.002 | .798 | .564 | .297 |
| 15 | 1.582 | 1.566 | 1.520 | 1.438 | 1.330 | 1.187 | 1.014 | .807 | .570 | .301 |
| 20 | 1.600 | 1.584 | 1.537 | 1.454 | 1.345 | 1.200 | 1.026 | .816 | .576 | .304 |
| 25 | 1.618 | 1.602 | 1.555 | 1.471 | 1.360 | 1.214 | 1.037 | .825 | .583 | .308 |
| 30 | 1.637 | 1.620 | 1.572 | 1.488 | 1.375 | 1.228 | 1.048 | .835 | .590 | .311 |
| 35 | 1.655 | 1.638 | 1.589 | 1.504 | 1.390 | 1.241 | 1.060 | .844 | .596 | .314 |
| 40 | 1.673 | 1.656 | 1.607 | 1.521 | 1.405 | 1.255 | 1.071 | .854 | .603 | .318 |

III.—TABLE OF LONG CHORDS.

| Radius in feet. | Angle of Deflection. | Length of Chord in feet required to subtend. | | | |
|--|----------------------|--|-------------|-------------|-------------|
| | | 1 Station. | 2 Stations. | 3 Stations. | 4 Stations. |
| 5730.0 | 1° | 100 | 200.0 | 300.0 | 400.0 |
| 4584.0 | $\frac{1}{2}$ | 100 | 200.0 | 300.0 | 399.9 |
| 3820.0 | $\frac{1}{4}$ | 100 | 200.0 | 300.0 | 399.9 |
| 3274.0 | $\frac{3}{4}$ | 100 | 200.0 | 300.0 | 399.8 |
| 2865.0 | 2° | 100 | 200.0 | 299.9 | 399.7 |
| 2547.0 | $\frac{1}{2}$ | 100 | 200.0 | 299.9 | 399.6 |
| 2292.0 | $\frac{1}{4}$ | 100 | 200.0 | 299.8 | 399.5 |
| 2084.0 | $\frac{3}{4}$ | 100 | 200.0 | 299.8 | 399.4 |
| 1910.0 | 3° | 100 | 200.0 | 299.7 | 399.3 |
| 1763.0 | $\frac{1}{2}$ | 100 | 200.0 | 299.7 | 399.2 |
| 1637.0 | $\frac{1}{4}$ | 100 | 200.0 | 299.6 | 399.1 |
| 1528.0 | $\frac{3}{4}$ | 100 | 200.0 | 299.6 | 399.0 |
| 1433.0 | 4° | 100 | 199.9 | 299.6 | 398.9 |
| 1348.0 | $\frac{1}{2}$ | 100 | 199.9 | 299.5 | 398.7 |
| 1274.0 | $\frac{1}{4}$ | 100 | 199.9 | 299.4 | 398.5 |
| 1207.0 | $\frac{3}{4}$ | 100 | 199.9 | 299.3 | 398.3 |
| 1146.0 | 5° | 100 | 199.9 | 299.2 | 398.0 |
| 1092.0 | $\frac{1}{2}$ | 100 | 199.8 | 299.1 | 397.8 |
| 1042.0 | $\frac{1}{4}$ | 100 | 199.8 | 299.0 | 397.6 |
| 996.8 | $\frac{3}{4}$ | 100 | 199.7 | 298.9 | 397.5 |
| 955.4 | 6° | 100 | 199.7 | 298.8 | 397.3 |
| 917.0 | $\frac{1}{2}$ | 100 | 199.7 | 298.7 | 397.0 |
| 882.0 | $\frac{1}{4}$ | 100 | 199.7 | 298.6 | 396.7 |
| 849.3 | $\frac{3}{4}$ | 100 | 199.6 | 298.5 | 396.5 |
| 819.0 | 7° | 100 | 199.6 | 298.4 | 396.2 |
| 790.8 | $\frac{1}{2}$ | 100 | 199.6 | 298.3 | 396.0 |
| 764.5 | $\frac{1}{4}$ | 100 | 199.6 | 298.2 | 395.7 |
| 739.9 | $\frac{3}{4}$ | 100 | 199.6 | 298.1 | 395.4 |
| 716.8 | 8° | 100 | 199.6 | 298.0 | 395.1 |
| 695.1 | $\frac{1}{2}$ | 100 | 199.5 | 297.9 | 394.8 |
| 674.6 | $\frac{1}{4}$ | 100 | 199.5 | 297.8 | 394.5 |
| 655.5 | $\frac{3}{4}$ | 100 | 199.4 | 297.7 | 394.3 |
| 637.3 | 9° | 100 | 199.4 | 297.5 | 394.1 |
| 620.2 | $\frac{1}{2}$ | 100 | 199.4 | 297.4 | 393.7 |
| 603.8 | $\frac{1}{4}$ | 100 | 199.3 | 297.3 | 393.2 |
| 588.4 | $\frac{3}{4}$ | 100 | 199.2 | 297.2 | 392.8 |
| 573.7 | 10° | 100 | 199.2 | 297.0 | 392.4 |
| For radii less than 573.7 feet, it is never required to use longer chords than 100 feet. | | | | | |

When this method of laying out curves by long chords is used, the instrument should be moved to each successive point after it is determined, in order to fix the next one, instead of attempting to obtain more than one point from one position of the instrument: because when the chords are longer than one chain, they cannot be measured in the right direction by eye, but must be guided by the instrument.

It must be especially borne in mind that, in any given curve, only the tangential and deflection *angles* increase in the same proportion as the

number of 100 feet stations subtended by the long chord. Therefore, *these* long chords cannot be used for laying out curves *by eye*, as their tangential and deflection *distances* are not known.

When it is required to use long chords for turning a curve *by eye*, they must be composed of a number of *whole chains*, being made say 200, 300, or 400, &c., feet in length. The tangential and deflection *distances* of curves of more than 500 feet radius may then be assumed, in practice, to increase as the *squares* of the number of chains in the length of the long chord. For instance, to lay off a 5° curve by chords of 200, 300, or 400 feet in length, the tangential and deflection distances of the table must be multiplied by 4, 9, or 16, as the case may be. In this case the tangential and deflection *angles* are unknown.

This is not mathematically correct, but will answer in practice for the curves of a canal or common road, where great nicety is not needed.

The only proper instrument for running lines of survey is the *transit*, furnished with a compass and with a revolving telescope. The deflections, being measured in *angles*, serve as a check to the numerous sources of error to which the compass is liable, arising from local attraction, electrical action in the glass cover, diurnal variation, &c. Besides, when the compass alone is used, it is necessary to test every course or bearing from each end of each station; and this involves loss of time.

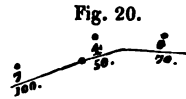
The following is a good form of field-book for the transit and compass combined :

| Station. | Distance. | Total Distance. | Course. | Deflection in Degrees. | The right hand page is left blank for Re- marks, and Sketches of Topography. |
|----------|-----------|--------------------|---------|---------------------------|---|
| | | | | Left. Right. | |

In every locating party there should be one person whose duty is to obtain and record the transverse slopes of the ground at each station. His observations will usually extend to from fifty feet to one hundred yards on each side of the centre stakes, depending on a variety of circumstances of locality which cannot be alluded to here. In preliminary locations these slopes need not be taken with very great nicety, as they will be used chiefly for ascertaining, approximately, the amount of excavation and embankment.

After the final location is made, the slopes should be taken again, with great care, to the nearest quarter of a degree; but need not extend beyond the width actually occupied by the road. Their use in this second operation will be for determining the cubic contents with more precision than before, for final estimates; and also for obtaining the positions of the *side-stakes*.

Should the duty of *recording* these slopes devolve upon the compass-man, (which it should not,) it will be necessary to add another column to his field-book after that containing the deflections. In this column he will insert the slopes thus, (fig. 20,) the dot representing the centre stake. The degrees of slope are written above the lines, and the distance in feet to which they extend, below.



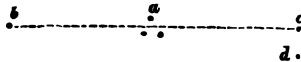
The slopes are taken by laying a long rod on the ground, at *right angles to the line of survey*, as nearly as may be judged by eye, and measuring the angles by means of a small *slope instrument* placed upon the rod. These are made by most of our instrument-makers.

ARTICLE XXII.

TO ADJUST A TRANSIT INSTRUMENT.

Having placed the transit firmly at *a*, fig. 21, and levelled it, clamp all fast, and direct the cross-hairs, by means of the tangent screw, to some convenient object *b*. Then, revolving the telescope *vertically*, but without moving it in the least *horizontally*, let the cross-hairs fix upon a second object in the opposite direction, as *c*; or, if there be no such object, place one, as for instance a chain-pin, at any convenient distance.

Fig. 21.



Then unclamp the *lower* clamp, and revolve *horizontally* the entire upper part of the instrument above the parallel plates. Clamp it again, and fix the cross-hairs upon *b*; then again revolve the *telescope* vertically. If the sight now strikes *c*, as before, it is in adjustment; but if not, place another object, *d*, where it does strike; and with the adjusting pin alter the vertical cross-hair so as to strike halfway between *d* and *c*. The instrument will then be in adjustment. Two or more trials will generally be needed before the adjustment is perfect.

With care, and on a firm floor, the operation may be performed in a long room, or by placing the instrument in a doorway communicating with two rooms of moderate size. Fine pins, or needles, should then be used as the objects to be sighted at. It is better, however, to adjust out of doors, with more distant objects. It is also a good precaution to hang up a long plumb-line, or select some vertical object, and see whether the vertical hair coincides with it, as the telescope is raised or lowered. If from any accident, or carelessness in its construction, it does not, the defect must be remedied by an instrument-maker.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 1 Deg. | | | | 1 Deg. | | | | 1 Deg. | | | |
|--------|-----------|----------|----------|----------|----|-------|-----------|----------|-----------|----|-------|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. |
| 0 | -0.174524 | -0.17455 | 57.28996 | .9998477 | 60 | 21 | -0.235598 | -0.23566 | -.9997224 | 39 | 41 |
| 1 | -0.177432 | -0.17746 | 56.35059 | .9998426 | 59 | 12 | -0.238506 | -0.23857 | -.9997156 | 38 | 42 |
| 2 | -0.180341 | -0.18037 | 55.44151 | .9998374 | 58 | 23 | -0.241414 | -0.24148 | -.9997086 | 37 | 43 |
| 3 | -0.183249 | -0.18328 | 54.56130 | .9998321 | 57 | 24 | -0.244322 | -0.24439 | -.9997015 | 36 | 44 |
| 4 | -0.186158 | -0.18619 | 53.70858 | .9998267 | 56 | 25 | -0.247230 | -0.24730 | -.9996943 | 35 | 45 |
| 5 | -0.189066 | -0.18910 | 52.88211 | .9998213 | 55 | 26 | -0.250138 | -0.25021 | -.9996871 | 34 | 46 |
| 6 | -0.191974 | -0.19201 | 52.08067 | .9998157 | 54 | 27 | -0.253046 | -0.25312 | -.9996798 | 33 | 47 |
| 7 | -0.194883 | -0.19492 | 51.30315 | .9998101 | 53 | 28 | -0.255954 | -0.25603 | -.9996724 | 32 | 48 |
| 8 | -0.197791 | -0.19783 | 50.54850 | .9998044 | 52 | 29 | -0.258862 | -0.25894 | -.9996649 | 31 | 49 |
| 9 | -0.200699 | -0.20074 | 49.81572 | .9997986 | 51 | 30 | -0.261769 | -0.26185 | -.9996573 | 30 | 50 |
| 10 | -0.203608 | -0.20365 | 49.10388 | .9997927 | 50 | 31 | -0.264677 | -0.26477 | -.9996497 | 29 | 51 |
| 11 | -0.206516 | -0.20656 | 48.41208 | .9997867 | 49 | 32 | -0.267585 | -0.26768 | -.9996419 | 28 | 52 |
| 12 | -0.209424 | -0.20947 | 47.73950 | .9997807 | 48 | 33 | -0.270493 | -0.27059 | -.9996341 | 27 | 53 |
| 13 | -0.212332 | -0.21238 | 47.08534 | .9997745 | 47 | 34 | -0.273401 | -0.27350 | -.9996262 | 26 | 54 |
| 14 | -0.215241 | -0.21529 | 46.44886 | .9997683 | 46 | 35 | -0.276309 | -0.27641 | -.9996182 | 25 | 55 |
| 15 | -0.218149 | -0.21820 | 45.82935 | .9997620 | 45 | 36 | -0.279216 | -0.27932 | -.9996101 | 24 | 56 |
| 16 | -0.221057 | -0.22111 | 45.22614 | .9997556 | 44 | 37 | -0.282124 | -0.28223 | -.9996020 | 23 | 57 |
| 17 | -0.223965 | -0.22402 | 44.63859 | .9997492 | 43 | 38 | -0.285032 | -0.28514 | -.9995939 | 22 | 58 |
| 18 | -0.226873 | -0.22693 | 44.06611 | .9997426 | 42 | 39 | -0.287940 | -0.28805 | -.9995854 | 21 | 59 |
| 19 | -0.229781 | -0.22984 | 43.50812 | .9997360 | 41 | 40 | -0.290847 | -0.29097 | -.9995770 | 20 | 60 |
| 20 | -0.232690 | -0.23275 | 42.96407 | .9997292 | 40 | | | | | | |

Deg. 88.

Deg. 88.

Deg. 88.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 2 Deg. | | | | 2 Deg. | | | | 2 Deg. | | | | | | | | | |
|--------|-----------|----------|----------|---------|----|-------|-----------|----------|----------|----------|-------|-------|-----------|----------|----------|----------|----|
| ' | Sine. | Tang. | Cotan. | Cosine. | ' | Sine. | Tang. | Cotan. | Cosine. | ' | Sine. | Tang. | Cotan. | Cosine. | ' | | |
| 0 | 0.0348995 | 0.034920 | 28.63625 | 9993908 | 60 | 21 | -0.410037 | -0.41038 | 24.36750 | -9991590 | 39 | 41 | -0.468159 | -0.46867 | 21.33685 | -9989035 | 19 |
| 1 | 0.0351902 | 0.035212 | 28.39939 | 9993806 | 59 | 22 | -0.412944 | -0.41329 | 24.19571 | -9991470 | 38 | 42 | -0.471065 | -0.47158 | 21.20494 | -9988999 | 18 |
| 2 | 0.0354809 | 0.035503 | 28.16642 | 9993704 | 58 | 23 | -0.415850 | -0.41621 | 24.02632 | -9991350 | 37 | 43 | -0.473970 | -0.47450 | 21.07466 | -9988761 | 17 |
| 3 | 0.0357716 | 0.035794 | 27.93723 | 9993600 | 57 | 24 | -0.418757 | -0.41912 | 23.85927 | -9991228 | 36 | 44 | -0.476876 | -0.47741 | 20.94596 | -9988523 | 16 |
| 4 | 0.0360623 | 0.036085 | 27.71174 | 9993495 | 56 | 25 | -0.421663 | -0.42203 | 23.69453 | -9991106 | 35 | 45 | -0.479781 | -0.48033 | 20.81182 | -9988284 | 15 |
| 5 | 0.0363530 | 0.036377 | 27.48985 | 9993390 | 55 | 26 | -0.424569 | -0.42493 | 23.53205 | -9990983 | 34 | 46 | -0.482687 | -0.48325 | 20.69322 | -9988044 | 14 |
| 6 | 0.0366437 | 0.036668 | 27.27148 | 9993284 | 54 | 27 | -0.427475 | -0.42786 | 23.37177 | -9990859 | 33 | 47 | -0.485592 | -0.48616 | 20.56911 | -9987803 | 13 |
| 7 | 0.0369344 | 0.036959 | 27.05655 | 9993177 | 53 | 28 | -0.430382 | -0.43078 | 23.21366 | -9990734 | 32 | 48 | -0.488498 | -0.48908 | 20.44648 | -9987561 | 12 |
| 8 | 0.0372251 | 0.037250 | 26.84498 | 9993069 | 52 | 29 | -0.433288 | -0.43369 | 23.05767 | -9990609 | 31 | 49 | -0.491403 | -0.49199 | 20.32530 | -9987319 | 11 |
| 9 | 0.0375158 | 0.037542 | 26.63669 | 9992960 | 51 | 30 | -0.436194 | -0.43660 | 22.90376 | -9990482 | 30 | 50 | -0.494308 | -0.49491 | 20.20555 | -9987075 | 10 |
| 10 | 0.0378065 | 0.037833 | 26.43160 | 9992851 | 50 | 31 | -0.439100 | -0.43952 | 22.75189 | -9990355 | 29 | 51 | -0.497214 | -0.49782 | 20.08719 | -9986831 | 9 |
| 11 | 0.0380971 | 0.038124 | 26.22963 | 9992740 | 49 | 32 | -0.442006 | -0.44243 | 22.60201 | -9990227 | 28 | 52 | -0.500119 | -0.50074 | 19.97021 | -9986586 | 8 |
| 12 | 0.0383878 | 0.038416 | 26.03073 | 9992629 | 48 | 33 | -0.444912 | -0.44535 | 22.45409 | -9990098 | 27 | 53 | -0.503024 | -0.50366 | 19.85459 | -9986340 | 7 |
| 13 | 0.0386785 | 0.038707 | 25.83482 | 9992517 | 47 | 34 | -0.447818 | -0.44826 | 22.30809 | -9989968 | 26 | 54 | -0.505929 | -0.50657 | 19.74029 | -9986094 | 6 |
| 14 | 0.0389692 | 0.038998 | 25.64183 | 9992404 | 46 | 35 | -0.450724 | -0.45118 | 22.16398 | -9989837 | 25 | 55 | -0.508835 | -0.50949 | 19.62729 | -9985848 | 5 |
| 15 | 0.0392598 | 0.039290 | 25.45170 | 9992290 | 45 | 36 | -0.453630 | -0.45409 | 22.02171 | -9989706 | 24 | 56 | -0.511740 | -0.51241 | 19.51558 | -9985602 | 4 |
| 16 | 0.0395505 | 0.039581 | 25.26436 | 9992176 | 44 | 37 | -0.456536 | -0.45701 | 21.88125 | -9989573 | 23 | 57 | -0.514645 | -0.51532 | 19.40513 | -9985356 | 3 |
| 17 | 0.0398411 | 0.039872 | 25.07975 | 9992060 | 43 | 38 | -0.459442 | -0.45992 | 21.74256 | -9989440 | 22 | 58 | -0.517550 | -0.51824 | 19.29592 | -9985110 | 2 |
| 18 | 0.0401318 | 0.040164 | 24.89782 | 9991944 | 42 | 39 | -0.462347 | -0.46284 | 21.60563 | -9989306 | 21 | 59 | -0.520455 | -0.52116 | 19.18793 | -9984864 | 1 |
| 19 | 0.0404224 | 0.040455 | 24.71851 | 9991827 | 41 | 40 | -0.465253 | -0.46575 | 21.47040 | -9989171 | 20 | 60 | -0.523360 | -0.52407 | 19.08113 | -9984618 | 0 |
| 20 | 0.0407131 | 0.040746 | 24.54175 | 9991709 | 40 | | | | | | | | | | | | |

Deg. 87.

Deg. 87.

Deg. 87.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 3 Deg. | | | | 3 Deg. | | | | 3 Deg. | | | | 3 Deg. | | | | | | | | | | | | | | | | | | | | | | | |
|--------|---|---------|---------|---------|---------|----|----|---------|---------|---------|---------|--------|----|---------|---------|---------|---------|----|----|---------|---------|---------|---------|----|----|---------|---------|---------|---------|----|----|---------|---------|---------|---------|
| ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. |
| 0 | 0 | 0.00000 | 0.00000 | ∞ | 1.00000 | 1 | 0 | 0.01746 | 0.01754 | 57.29 | 0.99999 | 2 | 0 | 0.03492 | 0.03496 | 57.29 | 0.99998 | 3 | 0 | 0.05236 | 0.05240 | 57.29 | 0.99997 | 4 | 0 | 0.06980 | 0.06984 | 57.29 | 0.99996 | 5 | 0 | 0.08724 | 0.08728 | 57.29 | 0.99995 |
| 1 | 0 | 0.01746 | 0.01754 | 57.29 | 0.99999 | 1 | 1 | 0.03492 | 0.03496 | 57.29 | 0.99998 | 2 | 1 | 0.05236 | 0.05240 | 57.29 | 0.99997 | 3 | 1 | 0.06980 | 0.06984 | 57.29 | 0.99996 | 4 | 1 | 0.08724 | 0.08728 | 57.29 | 0.99995 | 5 | 1 | 0.10468 | 0.10472 | 57.29 | 0.99994 |
| 2 | 0 | 0.03492 | 0.03496 | 57.29 | 0.99998 | 2 | 2 | 0.05236 | 0.05240 | 57.29 | 0.99997 | 3 | 2 | 0.06980 | 0.06984 | 57.29 | 0.99996 | 4 | 2 | 0.08724 | 0.08728 | 57.29 | 0.99995 | 5 | 2 | 0.10468 | 0.10472 | 57.29 | 0.99994 | 6 | 2 | 0.12212 | 0.12216 | 57.29 | 0.99993 |
| 3 | 0 | 0.05236 | 0.05240 | 57.29 | 0.99997 | 3 | 3 | 0.06980 | 0.06984 | 57.29 | 0.99996 | 4 | 3 | 0.08724 | 0.08728 | 57.29 | 0.99995 | 5 | 3 | 0.10468 | 0.10472 | 57.29 | 0.99994 | 6 | 3 | 0.12212 | 0.12216 | 57.29 | 0.99993 | 7 | 3 | 0.13956 | 0.13960 | 57.29 | 0.99992 |
| 4 | 0 | 0.06980 | 0.06984 | 57.29 | 0.99996 | 4 | 4 | 0.08724 | 0.08728 | 57.29 | 0.99995 | 5 | 4 | 0.10468 | 0.10472 | 57.29 | 0.99994 | 6 | 4 | 0.12212 | 0.12216 | 57.29 | 0.99993 | 7 | 4 | 0.13956 | 0.13960 | 57.29 | 0.99992 | 8 | 4 | 0.15700 | 0.15704 | 57.29 | 0.99991 |
| 5 | 0 | 0.08724 | 0.08728 | 57.29 | 0.99995 | 5 | 5 | 0.10468 | 0.10472 | 57.29 | 0.99994 | 6 | 5 | 0.12212 | 0.12216 | 57.29 | 0.99993 | 7 | 5 | 0.13956 | 0.13960 | 57.29 | 0.99992 | 8 | 5 | 0.15700 | 0.15704 | 57.29 | 0.99991 | 9 | 5 | 0.17444 | 0.17448 | 57.29 | 0.99990 |
| 6 | 0 | 0.10468 | 0.10472 | 57.29 | 0.99994 | 6 | 6 | 0.12212 | 0.12216 | 57.29 | 0.99993 | 7 | 6 | 0.13956 | 0.13960 | 57.29 | 0.99992 | 8 | 6 | 0.15700 | 0.15704 | 57.29 | 0.99991 | 9 | 6 | 0.17444 | 0.17448 | 57.29 | 0.99990 | 10 | 6 | 0.19188 | 0.19192 | 57.29 | 0.99989 |
| 7 | 0 | 0.12212 | 0.12216 | 57.29 | 0.99993 | 7 | 7 | 0.13956 | 0.13960 | 57.29 | 0.99992 | 8 | 7 | 0.15700 | 0.15704 | 57.29 | 0.99991 | 9 | 7 | 0.17444 | 0.17448 | 57.29 | 0.99990 | 10 | 7 | 0.19188 | 0.19192 | 57.29 | 0.99989 | 11 | 7 | 0.20932 | 0.20936 | 57.29 | 0.99988 |
| 8 | 0 | 0.13956 | 0.13960 | 57.29 | 0.99992 | 8 | 8 | 0.15700 | 0.15704 | 57.29 | 0.99991 | 9 | 8 | 0.17444 | 0.17448 | 57.29 | 0.99990 | 10 | 8 | 0.19188 | 0.19192 | 57.29 | 0.99989 | 11 | 8 | 0.20932 | 0.20936 | 57.29 | 0.99988 | 12 | 8 | 0.22676 | 0.22680 | 57.29 | 0.99987 |
| 9 | 0 | 0.15700 | 0.15704 | 57.29 | 0.99991 | 9 | 9 | 0.17444 | 0.17448 | 57.29 | 0.99990 | 10 | 9 | 0.19188 | 0.19192 | 57.29 | 0.99989 | 11 | 9 | 0.20932 | 0.20936 | 57.29 | 0.99988 | 12 | 9 | 0.22676 | 0.22680 | 57.29 | 0.99987 | 13 | 9 | 0.24420 | 0.24424 | 57.29 | 0.99986 |
| 10 | 0 | 0.17444 | 0.17448 | 57.29 | 0.99990 | 10 | 10 | 0.19188 | 0.19192 | 57.29 | 0.99989 | 11 | 10 | 0.20932 | 0.20936 | 57.29 | 0.99988 | 12 | 10 | 0.22676 | 0.22680 | 57.29 | 0.99987 | 13 | 10 | 0.24420 | 0.24424 | 57.29 | 0.99986 | 14 | 10 | 0.26164 | 0.26168 | 57.29 | 0.99985 |
| 11 | 0 | 0.19188 | 0.19192 | 57.29 | 0.99989 | 11 | 11 | 0.20932 | 0.20936 | 57.29 | 0.99988 | 12 | 11 | 0.22676 | 0.22680 | 57.29 | 0.99987 | 13 | 11 | 0.24420 | 0.24424 | 57.29 | 0.99986 | 14 | 11 | 0.26164 | 0.26168 | 57.29 | 0.99985 | 15 | 11 | 0.27908 | 0.27912 | 57.29 | 0.99984 |
| 12 | 0 | 0.20932 | 0.20936 | 57.29 | 0.99988 | 12 | 12 | 0.22676 | 0.22680 | 57.29 | 0.99987 | 13 | 12 | 0.24420 | 0.24424 | 57.29 | 0.99986 | 14 | 12 | 0.26164 | 0.26168 | 57.29 | 0.99985 | 15 | 12 | 0.27908 | 0.27912 | 57.29 | 0.99984 | 16 | 12 | 0.29652 | 0.29656 | 57.29 | 0.99983 |
| 13 | 0 | 0.22676 | 0.22680 | 57.29 | 0.99987 | 13 | 13 | 0.24420 | 0.24424 | 57.29 | 0.99986 | 14 | 13 | 0.26164 | 0.26168 | 57.29 | 0.99985 | 15 | 13 | 0.27908 | 0.27912 | 57.29 | 0.99984 | 16 | 13 | 0.29652 | 0.29656 | 57.29 | 0.99983 | 17 | 13 | 0.31396 | 0.31400 | 57.29 | 0.99982 |
| 14 | 0 | 0.24420 | 0.24424 | 57.29 | 0.99986 | 14 | 14 | 0.26164 | 0.26168 | 57.29 | 0.99985 | 15 | 14 | 0.27908 | 0.27912 | 57.29 | 0.99984 | 16 | 14 | 0.29652 | 0.29656 | 57.29 | 0.99983 | 17 | 14 | 0.31396 | 0.31400 | 57.29 | 0.99982 | 18 | 14 | 0.33140 | 0.33144 | 57.29 | 0.99981 |
| 15 | 0 | 0.26164 | 0.26168 | 57.29 | 0.99985 | 15 | 15 | 0.27908 | 0.27912 | 57.29 | 0.99984 | 16 | 15 | 0.29652 | 0.29656 | 57.29 | 0.99983 | 17 | 15 | 0.31396 | 0.31400 | 57.29 | 0.99982 | 18 | 15 | 0.33140 | 0.33144 | 57.29 | 0.99981 | 19 | 15 | 0.34884 | 0.34888 | 57.29 | 0.99980 |
| 16 | 0 | 0.27908 | 0.27912 | 57.29 | 0.99984 | 16 | 16 | 0.29652 | 0.29656 | 57.29 | 0.99983 | 17 | 16 | 0.31396 | 0.31400 | 57.29 | 0.99982 | 18 | 16 | 0.33140 | 0.33144 | 57.29 | 0.99981 | 19 | 16 | 0.34884 | 0.34888 | 57.29 | 0.99980 | 20 | 16 | 0.36628 | 0.36632 | 57.29 | 0.99979 |
| 17 | 0 | 0.29652 | 0.29656 | 57.29 | 0.99983 | 17 | 17 | 0.31396 | 0.31400 | 57.29 | 0.99982 | 18 | 17 | 0.33140 | 0.33144 | 57.29 | 0.99981 | 19 | 17 | 0.34884 | 0.34888 | 57.29 | 0.99980 | 20 | 17 | 0.36628 | 0.36632 | 57.29 | 0.99979 | 21 | 17 | 0.38372 | 0.38376 | 57.29 | 0.99978 |
| 18 | 0 | 0.31396 | 0.31400 | 57.29 | 0.99982 | 18 | 18 | 0.33140 | 0.33144 | 57.29 | 0.99981 | 19 | 18 | 0.34884 | 0.34888 | 57.29 | 0.99980 | 20 | 18 | 0.36628 | 0.36632 | 57.29 | 0.99979 | 21 | 18 | 0.38372 | 0.38376 | 57.29 | 0.99978 | 22 | 18 | 0.40116 | 0.40120 | 57.29 | 0.99977 |
| 19 | 0 | 0.33140 | 0.33144 | 57.29 | 0.99981 | 19 | 19 | 0.34884 | 0.34888 | 57.29 | 0.99980 | 20 | 19 | 0.36628 | 0.36632 | 57.29 | 0.99979 | 21 | 19 | 0.38372 | 0.38376 | 57.29 | 0.99978 | 22 | 19 | 0.40116 | 0.40120 | 57.29 | 0.99977 | 23 | 19 | 0.41860 | 0.41864 | 57.29 | 0.99976 |
| 20 | 0 | 0.34884 | 0.34888 | 57.29 | 0.99980 | 20 | 20 | 0.36628 | 0.36632 | 57.29 | 0.99979 | 21 | 20 | 0.38372 | 0.38376 | 57.29 | 0.99978 | 22 | 20 | 0.40116 | 0.40120 | 57.29 | 0.99977 | 23 | 20 | 0.41860 | 0.41864 | 57.29 | 0.99976 | 24 | 20 | 0.43604 | 0.43608 | 57.29 | 0.99975 |
| 21 | 0 | 0.36628 | 0.36632 | 57.29 | 0.99979 | 21 | 21 | 0.38372 | 0.38376 | 57.29 | 0.99978 | 22 | 21 | 0.40116 | 0.40120 | 57.29 | 0.99977 | 23 | 21 | 0.41860 | 0.41864 | 57.29 | 0.99976 | 24 | 21 | 0.43604 | 0.43608 | 57.29 | 0.99975 | 25 | 21 | 0.45348 | 0.45352 | 57.29 | 0.99974 |
| 22 | 0 | 0.38372 | 0.38376 | 57.29 | 0.99978 | 22 | 22 | 0.40116 | 0.40120 | 57.29 | 0.99977 | 23 | 22 | 0.41860 | 0.41864 | 57.29 | 0.99976 | 24 | 22 | 0.43604 | 0.43608 | 57.29 | 0.99975 | 25 | 22 | 0.45348 | 0.45352 | 57.29 | 0.99974 | 26 | 22 | 0.47092 | 0.47096 | 57.29 | 0.99973 |
| 23 | 0 | 0.40116 | 0.40120 | 57.29 | 0.99977 | 23 | 23 | 0.41860 | 0.41864 | 57.29 | 0.99976 | 24 | 23 | 0.43604 | 0.43608 | 57.29 | 0.99975 | 25 | 23 | 0.45348 | 0.45352 | 57.29 | 0.99974 | 26 | 23 | 0.47092 | 0.47096 | 57.29 | 0.99973 | 27 | 23 | 0.48836 | 0.48840 | 57.29 | 0.99972 |
| 24 | 0 | 0.41860 | 0.41864 | 57.29 | 0.99976 | 24 | 24 | 0.43604 | 0.43608 | 57.29 | 0.99975 | 25 | 24 | 0.45348 | 0.45352 | 57.29 | 0.99974 | 26 | 24 | 0.47092 | 0.47096 | 57.29 | 0.99973 | 27 | 24 | 0.48836 | 0.48840 | 57.29 | 0.99972 | 28 | 24 | 0.50580 | 0.50584 | 57.29 | 0.99971 |
| 25 | 0 | 0.43604 | 0.43608 | 57.29 | 0.99975 | 25 | 25 | 0.45348 | 0.45352 | 57.29 | 0.99974 | 26 | 25 | 0.47092 | 0.47096 | 57.29 | 0.99973 | 27 | 25 | 0.48836 | 0.48840 | 57.29 | 0.99972 | 28 | 25 | 0.50580 | 0.50584 | 57.29 | 0.99971 | 29 | 25 | 0.52324 | 0.52328 | 57.29 | 0.99970 |
| 26 | 0 | 0.45348 | 0.45352 | 57.29 | 0.99974 | 26 | 26 | 0.47092 | 0.47096 | 57.29 | 0.99973 | 27 | 26 | 0.48836 | 0.48840 | 57.29 | 0.99972 | 28 | 26 | 0.50580 | 0.50584 | 57.29 | 0.99971 | 29 | 26 | 0.52324 | 0.52328 | 57.29 | 0.99970 | 30 | 26 | 0.54068 | 0.54072 | 57.29 | 0.99969 |
| 27 | 0 | 0.47092 | 0.47096 | 57.29 | 0.99973 | 27 | 27 | 0.48836 | 0.48840 | 57.29 | 0.99972 | 28 | 27 | 0.50580 | 0.50584 | 57.29 | 0.99971 | 29 | 27 | 0.52324 | 0.52328 | 57.29 | 0.99970 | 30 | 27 | 0.54068 | 0.54072 | 57.29 | 0.99969 | 31 | 27 | 0.55812 | 0.55816 | 57.29 | 0.99968 |
| 28 | 0 | 0.48836 | 0.48840 | 57.29 | 0.99972 | 28 | 28 | 0.50580 | 0.50584 | 57.29 | 0.99971 | 29 | 28 | 0.52324 | 0.52328 | 57.29 | 0.99970 | 30 | 28 | 0.54068 | 0.54072 | 57.29 | 0.99969 | 31 | 28 | 0.55812 | 0.55816 | 57.29 | 0.99968 | 32 | 28 | 0.57556 | 0.57560 | 57.29 | 0.99967 |
| 29 | 0 | 0.50580 | 0.50584 | 57.29 | 0.99971 | 29 | 29 | 0.52324 | 0.52328 | 57.29 | 0.99970 | 30 | 29 | 0.54068 | 0.54072 | 57.29 | 0.99969 | 31 | 29 | 0.55812 | 0.55816 | 57.29 | 0.99968 | 32 | 29 | 0.57556 | 0.57560 | 57.29 | 0.99967 | 33 | 29 | 0.59300 | 0.59304 | 57.29 | 0.99966 |
| 30 | 0 | 0.52324 | 0.52328 | 57.29 | 0.99970 | 30 | 30 | 0.54068 | 0.54072 | 57.29 | 0.99969 | 31 | 30 | 0.55812 | 0.55816 | 57.29 | 0.99968 | 32 | 30 | 0.57556 | 0.57560 | 57.29 | 0.99967 | 33 | 30 | 0.59300 | 0.59304 | 57.29 | 0.99966 | 34 | 30 | 0.61044 | 0.61048 | 57.29 | 0.99965 |
| 31 | 0 | 0.54068 | 0.54072 | 57.29 | 0.99969 | 31 | 31 | 0.55812 | 0.55816 | 57.29 | 0.99968 | 32 | 31 | 0.57556 | 0.57560 | 57.29 | 0.99967 | 33 | 31 | 0.59300 | 0.59304 | 57.29 | 0.99966 | 34 | 31 | 0.61044 | 0.61048 | 57.29 | 0.99965 | 35 | 31 | 0.62748 | 0.62752 | 57.29 | 0.99964 |
| 32 | 0 | 0.55812 | 0.55816 | 57.29 | 0.99968 | 32 | 32 | 0.57556 | 0.57560 | 57.29 | 0.99967 | 33 | 32 | 0.59300 | 0.59304 | 57.29 | 0.99966 | 34 | 32 | 0.61044 | 0.61048 | 57.29 | 0.99965 | 35 | 32 | 0.62748 | 0.62752 | 57.29 | 0.99964 | 36 | 32 | 0.64492 | 0.64496 | 57.29 | 0.99963 |
| 33 | 0 | 0.57556 | 0.57560 | 57.29 | 0.99967 | 33 | 33 | 0.59300 | 0.59304 | 57.29 | 0.99966 | 34 | 33 | 0.61044 | 0.61048 | 57.29 | 0.99965 | 35 | 33 | 0.62748 | 0.62752 | 57.29 | 0.999 | | | | | | | | | | | | |

Deg. 86.

Deg. 86.

Deg. 86.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 4 Deg. | | | | 4 Deg. | | | | 4 Deg. | | | | 4 Deg. | | | | | |
|--------|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|--------|----------|---------|----------|----------|----|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
| 0 | .0697565 | .059926 | 14.30066 | .9975641 | 60 | 21 | .0758489 | .076068 | 13.14612 | .9971193 | 39 | 41 | .0816486 | .081922 | 12.20671 | .9966612 | 19 |
| 1 | .0700467 | .070219 | 14.24113 | .9975437 | 59 | 22 | .0761390 | .076360 | 13.09575 | .9970972 | 38 | 42 | .0819385 | .082215 | 12.16323 | .9966374 | 18 |
| 2 | .0703368 | .070511 | 14.18209 | .9975233 | 58 | 23 | .0764290 | .076653 | 13.04576 | .9970750 | 37 | 43 | .0822284 | .082507 | 12.12006 | .9966135 | 17 |
| 3 | .0706270 | .070803 | 14.12353 | .9975028 | 57 | 24 | .0767199 | .076945 | 12.99616 | .9970528 | 36 | 44 | .0825183 | .082800 | 12.07719 | .9965895 | 16 |
| 4 | .0709171 | .071096 | 14.06545 | .9974822 | 56 | 25 | .0770091 | .077238 | 12.94692 | .9970304 | 35 | 45 | .0828082 | .083093 | 12.03462 | .9965655 | 15 |
| 5 | .0712073 | .071388 | 14.00785 | .9974615 | 55 | 26 | .0772991 | .077531 | 12.89805 | .9970080 | 34 | 46 | .0830981 | .083386 | 11.99234 | .9965414 | 14 |
| 6 | .0714974 | .071680 | 13.95071 | .9974408 | 54 | 27 | .0775891 | .077823 | 12.84955 | .9969854 | 33 | 47 | .0833880 | .083679 | 11.95037 | .9965172 | 13 |
| 7 | .0717876 | .071973 | 13.89404 | .9974199 | 53 | 28 | .0778791 | .078116 | 12.80141 | .9969628 | 32 | 48 | .0836778 | .083972 | 11.90868 | .9964929 | 12 |
| 8 | .0720777 | .072265 | 13.83782 | .9973990 | 52 | 29 | .0781691 | .078409 | 12.75363 | .9969401 | 31 | 49 | .0839677 | .084265 | 11.86728 | .9964685 | 11 |
| 9 | .0723678 | .072558 | 13.78206 | .9973780 | 51 | 30 | .0784591 | .078701 | 12.70620 | .9969173 | 30 | 50 | .0842576 | .084558 | 11.82616 | .9964440 | 10 |
| 10 | .0726580 | .072850 | 13.72673 | .9973569 | 50 | 31 | .0787491 | .078994 | 12.65912 | .9968945 | 29 | 51 | .0845474 | .084851 | 11.78533 | .9964195 | 9 |
| 11 | .0729481 | .073143 | 13.67185 | .9973357 | 49 | 32 | .0790391 | .079287 | 12.61239 | .9968715 | 28 | 52 | .0848373 | .085144 | 11.74477 | .9963948 | 8 |
| 12 | .0732382 | .073435 | 13.61740 | .9973145 | 48 | 33 | .0793290 | .079579 | 12.56599 | .9968485 | 27 | 53 | .0851271 | .085437 | 11.70450 | .9963701 | 7 |
| 13 | .0735283 | .073727 | 13.56339 | .9972931 | 47 | 34 | .0796190 | .079872 | 12.51994 | .9968254 | 26 | 54 | .0854169 | .085730 | 11.66449 | .9963453 | 6 |
| 14 | .0738184 | .074020 | 13.50979 | .9972717 | 46 | 35 | .0799090 | .080165 | 12.47422 | .9968022 | 25 | 55 | .0857067 | .086023 | 11.62476 | .9963204 | 5 |
| 15 | .0741085 | .074312 | 13.45662 | .9972502 | 45 | 36 | .0801989 | .080458 | 12.42883 | .9967789 | 24 | 56 | .0859966 | .086316 | 11.58529 | .9962954 | 4 |
| 16 | .0743986 | .074605 | 13.40386 | .9972286 | 44 | 37 | .0804889 | .080750 | 12.38376 | .9967555 | 23 | 57 | .0862864 | .086609 | 11.54609 | .9962704 | 3 |
| 17 | .0746887 | .074897 | 13.35151 | .9972069 | 43 | 38 | .0807788 | .081043 | 12.33902 | .9967321 | 22 | 58 | .0865762 | .086902 | 11.50715 | .9962452 | 2 |
| 18 | .0749787 | .075190 | 13.29957 | .9971851 | 42 | 39 | .0810687 | .081336 | 12.29460 | .9967085 | 21 | 59 | .0868660 | .087195 | 11.46847 | .9962200 | 1 |
| 19 | .0752688 | .075482 | 13.24803 | .9971633 | 41 | 40 | .0813587 | .081629 | 12.25050 | .9966849 | 20 | 60 | .0871557 | .087488 | 11.43005 | .9961947 | 0 |
| 20 | .0755589 | .075775 | 13.19688 | .9971413 | 40 | | | | | | | | | | | | |

Deg. 85.

Deg. 85.

Deg. 85.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 5 Deg. | | | | | | | | | | 5 Deg. | | | | | | | | | | 5 Deg. | | | | | | | | | |
|--------|-----------|---------|----------|-----------|----|----|-----------|----------|----------|-----------|----|----|-----------|---------|-----------|-----------|----|---|-------|--------|---------|---------|---|---|-------|-------|---------|---------|---|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
| 0 | 0.0871557 | 0.87488 | 11.43005 | 0.9961947 | 60 | 21 | 0.9323395 | 0.933647 | 10.67834 | 0.9956437 | 39 | 41 | 0.9903303 | 0.99519 | 10.048280 | 0.9950844 | 19 | | | | | | | | | | | | |
| 1 | 0.0874455 | 0.87781 | 11.39188 | 0.9961693 | 59 | 22 | 0.935291 | 0.933940 | 10.64499 | 0.9956165 | 38 | 42 | 0.993197 | 0.99813 | 10.018710 | 0.9950556 | 18 | | | | | | | | | | | | |
| 2 | 0.0877353 | 0.88074 | 11.35397 | 0.9961438 | 58 | 23 | 0.938187 | 0.94234 | 10.61184 | 0.9955892 | 37 | 43 | 0.990092 | 1.00107 | 9.989305 | 0.9950266 | 17 | | | | | | | | | | | | |
| 3 | 0.0880251 | 0.88368 | 11.31630 | 0.9961183 | 57 | 24 | 0.941083 | 0.94527 | 10.57889 | 0.9955620 | 36 | 44 | 0.998986 | 1.00400 | 9.960072 | 0.9949976 | 16 | | | | | | | | | | | | |
| 4 | 0.0883148 | 0.88661 | 11.27888 | 0.9960926 | 56 | 25 | 0.943979 | 0.94921 | 10.54615 | 0.9955345 | 35 | 45 | 1.001881 | 1.00694 | 9.931008 | 0.9949685 | 15 | | | | | | | | | | | | |
| 5 | 0.0886046 | 0.88954 | 11.24171 | 0.9960669 | 55 | 26 | 0.946875 | 0.95114 | 10.51360 | 0.9955070 | 34 | 46 | 1.004775 | 1.00988 | 9.902112 | 0.9949393 | 14 | | | | | | | | | | | | |
| 6 | 0.0888943 | 0.89247 | 11.20478 | 0.9960411 | 54 | 27 | 0.949771 | 0.95408 | 10.48126 | 0.9954794 | 33 | 47 | 1.007669 | 1.01282 | 9.873382 | 0.9949101 | 13 | | | | | | | | | | | | |
| 7 | 0.0891840 | 0.89540 | 11.16808 | 0.9960152 | 53 | 28 | 0.952666 | 0.95701 | 10.44911 | 0.9954517 | 32 | 48 | 1.010563 | 1.01576 | 9.844816 | 0.9948807 | 12 | | | | | | | | | | | | |
| 8 | 0.0894738 | 0.89834 | 11.13163 | 0.9959892 | 52 | 29 | 0.955562 | 0.95995 | 10.41715 | 0.9954240 | 31 | 49 | 1.013457 | 1.01870 | 9.816414 | 0.9948513 | 11 | | | | | | | | | | | | |
| 9 | 0.0897635 | 0.90127 | 11.09541 | 0.9959631 | 51 | 30 | 0.958458 | 0.96289 | 10.38539 | 0.9953962 | 30 | 50 | 1.016351 | 1.02164 | 9.788173 | 0.9948217 | 10 | | | | | | | | | | | | |
| 10 | 0.0900532 | 0.90420 | 11.05943 | 0.9959370 | 50 | 31 | 0.961353 | 0.96582 | 10.35382 | 0.9953683 | 29 | 51 | 1.019245 | 1.02458 | 9.760092 | 0.9947921 | 9 | | | | | | | | | | | | |
| 11 | 0.0903429 | 0.90713 | 11.02367 | 0.9959107 | 49 | 32 | 0.964248 | 0.96876 | 10.32244 | 0.9953403 | 28 | 52 | 1.022138 | 1.02752 | 9.732171 | 0.9947625 | 8 | | | | | | | | | | | | |
| 12 | 0.0906326 | 0.91007 | 10.98815 | 0.9958844 | 48 | 33 | 0.967144 | 0.97169 | 10.29125 | 0.9953122 | 27 | 53 | 1.025032 | 1.03046 | 9.704407 | 0.9947327 | 7 | | | | | | | | | | | | |
| 13 | 0.0909223 | 0.91300 | 10.95285 | 0.9958580 | 47 | 34 | 0.970039 | 0.97463 | 10.26024 | 0.9952840 | 26 | 54 | 1.027925 | 1.03339 | 9.676800 | 0.9947028 | 6 | | | | | | | | | | | | |
| 14 | 0.0912119 | 0.91593 | 10.91777 | 0.9958315 | 46 | 35 | 0.972934 | 0.97757 | 10.22942 | 0.9952557 | 25 | 55 | 1.030819 | 1.03634 | 9.649347 | 0.9946729 | 5 | | | | | | | | | | | | |
| 15 | 0.0915016 | 0.91887 | 10.88292 | 0.9958049 | 45 | 36 | 0.975829 | 0.98050 | 10.19878 | 0.9952274 | 24 | 56 | 1.033712 | 1.03928 | 9.622048 | 0.9946428 | 4 | | | | | | | | | | | | |
| 16 | 0.0917913 | 0.92180 | 10.84828 | 0.9957783 | 44 | 37 | 0.978724 | 0.98344 | 10.16833 | 0.9951990 | 23 | 57 | 1.036605 | 1.04222 | 9.594902 | 0.9946127 | 3 | | | | | | | | | | | | |
| 17 | 0.0920809 | 0.92473 | 10.81387 | 0.9957515 | 43 | 38 | 0.981619 | 0.98838 | 10.13805 | 0.9951705 | 22 | 58 | 1.039499 | 1.04516 | 9.567906 | 0.9945825 | 2 | | | | | | | | | | | | |
| 18 | 0.0923706 | 0.92767 | 10.77967 | 0.9957247 | 42 | 39 | 0.984514 | 0.98932 | 10.10795 | 0.9951419 | 21 | 59 | 1.042392 | 1.04810 | 9.541061 | 0.9945523 | 1 | | | | | | | | | | | | |
| 19 | 0.0926602 | 0.93060 | 10.74568 | 0.9956978 | 41 | 40 | 0.987408 | 0.99225 | 10.07803 | 0.9951132 | 20 | 60 | 1.045285 | 1.05104 | 9.514364 | 0.9945219 | 0 | | | | | | | | | | | | |
| 20 | 0.0929499 | 0.93354 | 10.71191 | 0.9956708 | 40 | | | | | | | | | | | | | | | | | | | | | | | | |

Deg. 84.

Deg. 84.

Deg. 84.

6 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|
| 0 | 1045285 | 105104 | 9514364 | 9945219 | 60 | 21 | 1106017 | 111284 | 8985984 | 9938648 | 39 | 41 | 1163818 | 117178 | 8534017 | 9932045 | 19 |
| 1 | 1048178 | 105398 | 9487814 | 9944914 | 59 | 22 | 1110890 | 111378 | 8962266 | 9938326 | 38 | 42 | 1166707 | 117473 | 8512594 | 9931706 | 18 |
| 2 | 1051070 | 105692 | 9461411 | 9944609 | 58 | 23 | 1111799 | 111673 | 8938672 | 9938003 | 37 | 43 | 1169596 | 117767 | 8491277 | 9931367 | 17 |
| 3 | 1053963 | 105986 | 9435153 | 9944303 | 57 | 24 | 1114689 | 112187 | 8915200 | 9937679 | 36 | 44 | 1172485 | 118062 | 8470065 | 9931026 | 16 |
| 4 | 1056856 | 106280 | 9409038 | 9943996 | 56 | 25 | 1117580 | 112462 | 8891350 | 9937355 | 35 | 45 | 1175374 | 118357 | 8448957 | 9930685 | 15 |
| 5 | 1059748 | 106575 | 9383066 | 9943688 | 55 | 26 | 1120471 | 112757 | 8868620 | 9937029 | 34 | 46 | 1178263 | 118652 | 8427953 | 9930342 | 14 |
| 6 | 1062641 | 106869 | 9357235 | 9943379 | 54 | 27 | 1123361 | 113051 | 8845510 | 9936703 | 33 | 47 | 1181151 | 118947 | 8407051 | 9929999 | 13 |
| 7 | 1065533 | 107163 | 9331545 | 9943070 | 53 | 28 | 1126252 | 113346 | 8822518 | 9936375 | 32 | 48 | 1184040 | 119242 | 8386251 | 9929655 | 12 |
| 8 | 1068425 | 107457 | 9305993 | 9942760 | 52 | 29 | 1129142 | 113641 | 8799644 | 9936047 | 31 | 49 | 1186928 | 119537 | 8365553 | 9929310 | 11 |
| 9 | 1071318 | 107751 | 9280580 | 9942448 | 51 | 30 | 1132032 | 113935 | 8776887 | 9935719 | 30 | 50 | 1189816 | 119832 | 8344955 | 9928965 | 10 |
| 10 | 1074210 | 108046 | 9255303 | 9942136 | 50 | 31 | 1134922 | 114230 | 8754246 | 9935389 | 29 | 51 | 1192704 | 120127 | 8324457 | 9928618 | 9 |
| 11 | 1077102 | 108340 | 9230152 | 9941823 | 49 | 32 | 1137812 | 114525 | 8731719 | 9935058 | 28 | 52 | 1195593 | 120423 | 8304058 | 9928271 | 8 |
| 12 | 1079994 | 108634 | 9205156 | 9941510 | 48 | 33 | 1140702 | 114819 | 8709307 | 9934727 | 27 | 53 | 1198481 | 120718 | 8283757 | 9927927 | 7 |
| 13 | 1082885 | 108929 | 9180283 | 9941195 | 47 | 34 | 1143592 | 115114 | 8686708 | 9934395 | 26 | 54 | 1201368 | 121013 | 8263554 | 9927573 | 6 |
| 14 | 1085777 | 109223 | 9155543 | 9940880 | 46 | 35 | 1146482 | 115409 | 8664822 | 9934062 | 25 | 55 | 1204256 | 121308 | 8243448 | 9927224 | 5 |
| 15 | 1088669 | 109517 | 9130934 | 9940563 | 45 | 36 | 1149372 | 115703 | 8642477 | 9933728 | 24 | 56 | 1207144 | 121603 | 8223438 | 9926873 | 4 |
| 16 | 1091560 | 109812 | 9106456 | 9940246 | 44 | 37 | 1152261 | 115998 | 8620783 | 9933393 | 23 | 57 | 1210031 | 121898 | 8203523 | 9926521 | 3 |
| 17 | 1094432 | 110106 | 9082107 | 9939928 | 43 | 38 | 1155151 | 116293 | 8598729 | 9933057 | 22 | 58 | 1212919 | 122194 | 8183704 | 9926169 | 2 |
| 18 | 1097343 | 110401 | 9057886 | 9939610 | 42 | 39 | 1158040 | 116588 | 8579713 | 9932721 | 21 | 59 | 1215806 | 122489 | 8163978 | 9925816 | 1 |
| 19 | 1100234 | 110695 | 9033793 | 9939290 | 41 | 40 | 1160929 | 116883 | 8555546 | 9932384 | 20 | 60 | 1218693 | 122784 | 8144346 | 9925462 | 0 |
| 20 | 1103126 | 110989 | 9009826 | 9938969 | 40 | | | | | | | | | | | | |
| ° | Cosine. | Cotan. | Tang. | Sine. | ' | ' | Cosine. | Cotan. | Tang. | Sine. | ' | ' | Cosine. | Cotan. | Tang. | Sine. | ' |

Dez. 83.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

7 Deg.

7 Deg.

7 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|---------|---------|----|-------|---------|---------|---------|---------|-------|-------|---------|---------|---------|
| 0 | 1218693 | 122784 | 8144346 | 9925462 | 60 | 21 | 1279302 | 128990 | 7752536 | 9917832 | 39 | 41 | 1336979 | 134909 | 7412397 |
| 1 | 1221581 | 123079 | 8124807 | 9925107 | 59 | 22 | 1282186 | 129285 | 7734802 | 9917459 | 38 | 42 | 1339862 | 135205 | 7396159 |
| 2 | 1224468 | 123375 | 8105359 | 9924751 | 58 | 23 | 1285071 | 129581 | 7717148 | 9917086 | 37 | 43 | 1342744 | 135501 | 7379990 |
| 3 | 1227355 | 123670 | 8086004 | 9924394 | 57 | 24 | 1287956 | 129877 | 7699573 | 9916712 | 36 | 44 | 1345627 | 135797 | 7363891 |
| 4 | 1230241 | 123965 | 8066739 | 9924037 | 56 | 25 | 1290841 | 130173 | 7682076 | 9916337 | 35 | 45 | 1348509 | 136094 | 7347861 |
| 5 | 1233128 | 124261 | 8047564 | 9923679 | 55 | 26 | 1293725 | 130469 | 7664658 | 9915961 | 34 | 46 | 1351392 | 136390 | 7331898 |
| 6 | 1236015 | 124556 | 8028479 | 9923319 | 54 | 27 | 1296609 | 130764 | 7647517 | 9915584 | 33 | 47 | 1354274 | 136686 | 7316004 |
| 7 | 1238901 | 124852 | 8009483 | 9922959 | 53 | 28 | 1299494 | 131060 | 7630053 | 9915206 | 32 | 48 | 1357156 | 136983 | 7300178 |
| 8 | 1241788 | 125147 | 7990375 | 9922599 | 52 | 29 | 1302378 | 131356 | 7612865 | 9914828 | 31 | 49 | 1360038 | 137279 | 7284418 |
| 9 | 1244674 | 125442 | 7971755 | 9922237 | 51 | 30 | 1305262 | 131652 | 7595754 | 9914449 | 30 | 50 | 1362919 | 137575 | 7268725 |
| 10 | 1247560 | 125738 | 7953022 | 9921874 | 50 | 31 | 1308146 | 131948 | 7578717 | 9914069 | 29 | 51 | 1365801 | 137872 | 7253098 |
| 11 | 1250446 | 126033 | 7934375 | 9921511 | 49 | 32 | 1311030 | 132244 | 7561756 | 9913688 | 28 | 52 | 1368683 | 138168 | 7237537 |
| 12 | 1253332 | 126329 | 7915815 | 9921147 | 48 | 33 | 1313913 | 132540 | 7544869 | 9913306 | 27 | 53 | 1371564 | 138465 | 7222042 |
| 13 | 1256218 | 126624 | 7897339 | 9920782 | 47 | 34 | 1316797 | 132836 | 7528057 | 9912923 | 26 | 54 | 1374445 | 138761 | 7206611 |
| 14 | 1259104 | 126920 | 7878948 | 9920416 | 46 | 35 | 1319681 | 133132 | 7511317 | 9912540 | 25 | 55 | 1377327 | 139058 | 7191245 |
| 15 | 1261990 | 127216 | 7860642 | 9920049 | 45 | 36 | 1322564 | 133428 | 7494651 | 9912155 | 24 | 56 | 1380208 | 139354 | 7175943 |
| 16 | 1264875 | 127511 | 7842419 | 9919682 | 44 | 37 | 1325447 | 133724 | 7478057 | 9911770 | 23 | 57 | 1383089 | 139651 | 7160705 |
| 17 | 1267761 | 127807 | 7824279 | 9919314 | 43 | 38 | 1328330 | 134020 | 7461537 | 9911384 | 22 | 58 | 1385970 | 139947 | 7145530 |
| 18 | 1270646 | 128103 | 7806221 | 9918944 | 42 | 39 | 1331213 | 134316 | 7445085 | 9910997 | 21 | 59 | 1388850 | 140244 | 7130419 |
| 19 | 1273531 | 128398 | 7788245 | 9918574 | 41 | 40 | 1334096 | 134612 | 7428706 | 9910610 | 20 | 60 | 1391731 | 140540 | 7115369 |
| 20 | 1276416 | 128694 | 7770350 | 9918204 | 40 | | | | | | | | | | |

Deg. 82.

Deg. 82.

Deg. 82.

| ' | Cosine. | Cotan. | Tang. | Sine. | ' | Cosine. | Cotan. | Tang. | Sine. | ' |
|---|---------|--------|---------|---------|----|---------|--------|-------|-------|---|
| ' | 9910221 | 134909 | 7412397 | 9910221 | 19 | | | | | |
| | 9909832 | 135205 | 7396159 | 9909832 | 18 | | | | | |
| | 9909442 | 135501 | 7379990 | 9909442 | 17 | | | | | |
| | 9909051 | 135797 | 7363891 | 9909051 | 16 | | | | | |
| | 9908659 | 136094 | 7347861 | 9908659 | 15 | | | | | |
| | 9908266 | 136390 | 7331898 | 9908266 | 14 | | | | | |
| | 9907873 | 136686 | 7316004 | 9907873 | 13 | | | | | |
| | 9907478 | 136983 | 7300178 | 9907478 | 12 | | | | | |
| | 9907083 | 137279 | 7284418 | 9907083 | 11 | | | | | |
| | 9906687 | 137575 | 7268725 | 9906687 | 10 | | | | | |
| | 9906290 | 137872 | 7253098 | 9906290 | 9 | | | | | |
| | 9905893 | 138168 | 7237537 | 9905893 | 8 | | | | | |
| | 9905494 | 138465 | 7222042 | 9905494 | 7 | | | | | |
| | 9905095 | 138761 | 7206611 | 9905095 | 6 | | | | | |
| | 9904694 | 139058 | 7191245 | 9904694 | 5 | | | | | |
| | 9904293 | 139354 | 7175943 | 9904293 | 4 | | | | | |
| | 9903891 | 139651 | 7160705 | 9903891 | 3 | | | | | |
| | 9903489 | 139947 | 7145530 | 9903489 | 2 | | | | | |
| | 9903085 | 140244 | 7130419 | 9903085 | 1 | | | | | |
| | 9902681 | 140540 | 7115369 | 9902681 | 0 | | | | | |

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

8 Deg.

8 Deg.

8 Deg.

| | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .1391731 | .140540 | 7.115369 | .9902681 | 60 | 21 | .1452197 | .146775 | 6.813122 | .9893994 | 39 | 41 | .1509733 | .152723 | 6.547767 | .9885378 | 19 |
| 1 | .1394612 | .140837 | 7.100382 | .9902275 | 59 | 22 | .1455075 | .147072 | 6.799356 | .9893572 | 38 | 42 | .1512608 | .153021 | 6.535029 | .9884939 | 18 |
| 2 | .1397492 | .141134 | 7.085457 | .9901869 | 58 | 23 | .1457953 | .147369 | 6.785644 | .9893148 | 37 | 43 | .1515484 | .153319 | 6.522339 | .9884498 | 17 |
| 3 | .1400372 | .141430 | 7.070593 | .9901462 | 57 | 24 | .1460830 | .147667 | 6.771986 | .9892723 | 36 | 44 | .1518359 | .153617 | 6.509698 | .9884057 | 16 |
| 4 | .1403252 | .141727 | 7.055790 | .9901055 | 56 | 25 | .1463708 | .147964 | 6.758382 | .9892298 | 35 | 45 | .1521234 | .153914 | 6.497104 | .9883615 | 15 |
| 5 | .1406132 | .142024 | 7.041048 | .9900646 | 55 | 26 | .1466585 | .148261 | 6.744831 | .9891872 | 34 | 46 | .1524109 | .154212 | 6.484558 | .9883172 | 14 |
| 6 | .1409012 | .142321 | 7.026366 | .9900237 | 54 | 27 | .1469463 | .148559 | 6.731334 | .9891445 | 33 | 47 | .1526984 | .154510 | 6.472059 | .9882728 | 13 |
| 7 | .1411892 | .142617 | 7.011744 | .9899826 | 53 | 28 | .1472340 | .148856 | 6.717889 | .9891017 | 32 | 48 | .1529858 | .154808 | 6.459607 | .9882284 | 12 |
| 8 | .1414772 | .142914 | 6.997180 | .9899415 | 52 | 29 | .1475217 | .149153 | 6.704496 | .9890588 | 31 | 49 | .1532733 | .155106 | 6.447201 | .9881838 | 11 |
| 9 | .1417651 | .143211 | 6.982678 | .9899003 | 51 | 30 | .1478094 | .149451 | 6.691156 | .9890159 | 30 | 50 | .1535607 | .155404 | 6.434842 | .9881392 | 10 |
| 10 | .1420531 | .143508 | 6.968233 | .9898590 | 50 | 31 | .1480971 | .149748 | 6.677867 | .9889728 | 29 | 51 | .1538482 | .155701 | 6.422530 | .9880945 | 9 |
| 11 | .1423410 | .143805 | 6.953847 | .9898177 | 49 | 32 | .1483848 | .150045 | 6.664630 | .9889297 | 28 | 52 | .1541356 | .155999 | 6.410263 | .9880497 | 8 |
| 12 | .1426289 | .144102 | 6.939519 | .9897762 | 48 | 33 | .1486724 | .150343 | 6.651444 | .9888865 | 27 | 53 | .1544230 | .156297 | 6.398042 | .9880048 | 7 |
| 13 | .1429168 | .144399 | 6.925248 | .9897347 | 47 | 34 | .1489601 | .150640 | 6.638310 | .9888432 | 26 | 54 | .1547104 | .156595 | 6.385866 | .9879599 | 6 |
| 14 | .1432047 | .144696 | 6.911035 | .9896931 | 46 | 35 | .1492477 | .150938 | 6.625225 | .9887998 | 25 | 55 | .1549978 | .156893 | 6.373735 | .9879148 | 5 |
| 15 | .1434926 | .144993 | 6.896879 | .9896514 | 45 | 36 | .1495353 | .151235 | 6.612191 | .9887564 | 24 | 56 | .1552851 | .157191 | 6.361650 | .9878697 | 4 |
| 16 | .1437805 | .145290 | 6.882780 | .9896096 | 44 | 37 | .1498230 | .151533 | 6.599208 | .9887128 | 23 | 57 | .1555725 | .157490 | 6.349609 | .9878245 | 3 |
| 17 | .1440684 | .145587 | 6.868737 | .9895677 | 43 | 38 | .1501106 | .151830 | 6.586273 | .9886692 | 22 | 58 | .1558598 | .157788 | 6.337612 | .9877792 | 2 |
| 18 | .1443562 | .145884 | 6.854750 | .9895258 | 42 | 39 | .1503981 | .152128 | 6.573389 | .9886255 | 21 | 59 | .1561472 | .158086 | 6.325660 | .9877338 | 1 |
| 19 | .1446440 | .146181 | 6.840819 | .9894838 | 41 | 40 | .1506857 | .152426 | 6.560553 | .9885817 | 20 | 60 | .1564345 | .158384 | 6.313751 | .9876883 | 0 |
| 20 | .1449319 | .146478 | 6.826943 | .9894416 | 40 | | | | | | | | | | | | |

Deg. 81.

Deg. 81.

Deg. 81.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

9 Deg.

9 Deg.

9 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .1564345 | .158384 | 6.313751 | .9876883 | 60 | 21 | .1624650 | .164652 | 6.073307 | .9867143 | 39 | 41 | .1682026 | .170633 | 5.860505 | .9857524 | 19 |
| 1 | .1567218 | .158682 | 6.301886 | .9876428 | 59 | 22 | .1627520 | .164951 | 6.062396 | .9866670 | 38 | 42 | .1684894 | .170933 | 5.850241 | .9857035 | 18 |
| 2 | .1570091 | .158980 | 6.290065 | .9875972 | 58 | 23 | .1630390 | .165250 | 6.051434 | .9866196 | 37 | 43 | .1687761 | .171232 | 5.840011 | .9856544 | 17 |
| 3 | .1572963 | .159279 | 6.278286 | .9875514 | 57 | 24 | .1633260 | .165548 | 6.040510 | .9865722 | 36 | 44 | .1690628 | .171532 | 5.829817 | .9856053 | 16 |
| 4 | .1575836 | .159577 | 6.266551 | .9875057 | 56 | 25 | .1636129 | .165847 | 6.029624 | .9865246 | 35 | 45 | .1693495 | .171831 | 5.819557 | .9855561 | 15 |
| 5 | .1578708 | .159875 | 6.254858 | .9874598 | 55 | 26 | .1638999 | .166146 | 6.018777 | .9864770 | 34 | 46 | .1696362 | .172130 | 5.809331 | .9855068 | 14 |
| 6 | .1581581 | .160174 | 6.243208 | .9874138 | 54 | 27 | .1641868 | .166445 | 6.007967 | .9864293 | 33 | 47 | .1699228 | .172430 | 5.799440 | .9854574 | 13 |
| 7 | .1584453 | .160472 | 6.231600 | .9873678 | 53 | 28 | .1644738 | .166744 | 5.997195 | .9863815 | 32 | 48 | .1702095 | .172730 | 5.789382 | .9854079 | 12 |
| 8 | .1587325 | .160770 | 6.220034 | .9873216 | 52 | 29 | .1647607 | .167043 | 5.986461 | .9863336 | 31 | 49 | .1704961 | .173029 | 5.779358 | .9853583 | 11 |
| 9 | .1590197 | .161069 | 6.208510 | .9872754 | 51 | 30 | .1650476 | .167342 | 5.975764 | .9862856 | 30 | 50 | .1707828 | .173329 | 5.769368 | .9853087 | 10 |
| 10 | .1593069 | .161367 | 6.197027 | .9872291 | 50 | 31 | .1653345 | .167641 | 5.965104 | .9862375 | 29 | 51 | .1710694 | .173628 | 5.759412 | .9852590 | 9 |
| 11 | .1595940 | .161666 | 6.185586 | .9871827 | 49 | 32 | .1656214 | .167940 | 5.954481 | .9861894 | 28 | 52 | .1713560 | .173928 | 5.749488 | .9852092 | 8 |
| 12 | .1598812 | .161964 | 6.174186 | .9871363 | 48 | 33 | .1659082 | .168239 | 5.943895 | .9861412 | 27 | 53 | .1716425 | .174228 | 5.739598 | .9851593 | 7 |
| 13 | .1601683 | .162263 | 6.162827 | .9870897 | 47 | 34 | .1661951 | .168539 | 5.933345 | .9860929 | 26 | 54 | .1719291 | .174527 | 5.729741 | .9851093 | 6 |
| 14 | .1604553 | .162561 | 6.151508 | .9870431 | 46 | 35 | .1664819 | .168838 | 5.922832 | .9860445 | 25 | 55 | .1722156 | .174827 | 5.719917 | .9850593 | 5 |
| 15 | .1607426 | .162860 | 6.140230 | .9869964 | 45 | 36 | .1667687 | .169137 | 5.912355 | .9859960 | 24 | 56 | .1725022 | .175127 | 5.710125 | .9850091 | 4 |
| 16 | .1610297 | .163159 | 6.128992 | .9869496 | 44 | 37 | .1670556 | .169436 | 5.901913 | .9859475 | 23 | 57 | .1727887 | .175427 | 5.700366 | .9849589 | 3 |
| 17 | .1613167 | .163457 | 6.117794 | .9869027 | 43 | 38 | .1673423 | .169735 | 5.891508 | .9858988 | 22 | 58 | .1730752 | .175727 | 5.690639 | .9849086 | 2 |
| 18 | .1616038 | .163756 | 6.106636 | .9868557 | 42 | 39 | .1676291 | .170035 | 5.881138 | .9858501 | 21 | 59 | .1733617 | .176027 | 5.680944 | .9848582 | 1 |
| 19 | .1618909 | .164055 | 6.095517 | .9868087 | 41 | 40 | .1679159 | .170334 | 5.870804 | .9858013 | 20 | 60 | .1736482 | .176327 | 5.671281 | .9848078 | 0 |
| 20 | .1621779 | .164353 | 6.084438 | .9867615 | 40 | | | | | | | | | | | | |

Deg. 80.

Deg. 80.

Deg. 80.

| ° | Cosine. | Cotan. | Tang. | Sine. | ' | ' | Cosine. | Cotan. | Tang. | Sine. | ' | ' | Cosine. | Cotan. | Tang. | Sine. | ' |
|----|----------|--------|-------|-------|---|---|----------|--------|-------|-------|---|---|----------|--------|-------|-------|---|
| 0 | .9857524 | 19 | | | | | .9857524 | 19 | | | | | .9857524 | 19 | | | |
| 1 | .9857035 | 18 | | | | | .9857035 | 18 | | | | | .9857035 | 18 | | | |
| 2 | .9856544 | 17 | | | | | .9856544 | 17 | | | | | .9856544 | 17 | | | |
| 3 | .9856053 | 16 | | | | | .9856053 | 16 | | | | | .9856053 | 16 | | | |
| 4 | .9855561 | 15 | | | | | .9855561 | 15 | | | | | .9855561 | 15 | | | |
| 5 | .9855068 | 14 | | | | | .9855068 | 14 | | | | | .9855068 | 14 | | | |
| 6 | .9854574 | 13 | | | | | .9854574 | 13 | | | | | .9854574 | 13 | | | |
| 7 | .9854079 | 12 | | | | | .9854079 | 12 | | | | | .9854079 | 12 | | | |
| 8 | .9853583 | 11 | | | | | .9853583 | 11 | | | | | .9853583 | 11 | | | |
| 9 | .9853087 | 10 | | | | | .9853087 | 10 | | | | | .9853087 | 10 | | | |
| 10 | .9852590 | 9 | | | | | .9852590 | 9 | | | | | .9852590 | 9 | | | |
| 11 | .9852092 | 8 | | | | | .9852092 | 8 | | | | | .9852092 | 8 | | | |
| 12 | .9851593 | 7 | | | | | .9851593 | 7 | | | | | .9851593 | 7 | | | |
| 13 | .9851093 | 6 | | | | | .9851093 | 6 | | | | | .9851093 | 6 | | | |
| 14 | .9850593 | 5 | | | | | .9850593 | 5 | | | | | .9850593 | 5 | | | |
| 15 | .9850091 | 4 | | | | | .9850091 | 4 | | | | | .9850091 | 4 | | | |
| 16 | .9849589 | 3 | | | | | .9849589 | 3 | | | | | .9849589 | 3 | | | |
| 17 | .9849086 | 2 | | | | | .9849086 | 2 | | | | | .9849086 | 2 | | | |
| 18 | .9848582 | 1 | | | | | .9848582 | 1 | | | | | .9848582 | 1 | | | |
| 19 | .9848078 | 0 | | | | | .9848078 | 0 | | | | | .9848078 | 0 | | | |

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 10 Deg. | | | | 10 Deg. | | | | 10 Deg. | | | | Deg. 79. | | | | |
|---------|---------|--------|----------|---------|----|-------|---------|---------|----------|---------|-------|----------|---------|----------|----------|---|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | |
| 0 | 1736482 | 176327 | 5.671281 | 9848078 | 60 | 21 | 1796607 | 182632 | 5.475478 | 9837286 | 39 | 41 | 1853808 | 188650 | 19 | |
| 1 | 1739346 | 176626 | 5.661650 | 9847572 | 59 | 22 | 1799469 | 182933 | 5.466481 | 9836763 | 38 | 42 | 1856666 | 188952 | 18 | |
| 2 | 1742211 | 176926 | 5.652051 | 9847066 | 58 | 23 | 1802330 | 183233 | 5.457512 | 9836239 | 37 | 43 | 1859524 | 189253 | 17 | |
| 3 | 1745075 | 177226 | 5.642483 | 9846558 | 57 | 24 | 1805191 | 183534 | 5.448571 | 9835715 | 36 | 44 | 1862382 | 189554 | 16 | |
| 4 | 1747939 | 177527 | 5.632947 | 9846050 | 56 | 25 | 1808052 | 183835 | 5.439659 | 9835189 | 35 | 45 | 1865240 | 189855 | 15 | |
| 5 | 1750803 | 177827 | 5.623442 | 9845542 | 55 | 26 | 1810913 | 184135 | 5.430775 | 9834663 | 34 | 46 | 1868098 | 190157 | 14 | |
| 6 | 1753667 | 178127 | 5.613968 | 9845032 | 54 | 27 | 1813774 | 184436 | 5.421918 | 9834136 | 33 | 47 | 1870956 | 190458 | 13 | |
| 7 | 1756531 | 178427 | 5.604524 | 9844521 | 53 | 28 | 1816635 | 184737 | 5.413090 | 9833608 | 32 | 48 | 1873813 | 190760 | 12 | |
| 8 | 1759395 | 178727 | 5.595112 | 9844010 | 52 | 29 | 1819495 | 185038 | 5.404290 | 9833079 | 31 | 49 | 1876670 | 191061 | 11 | |
| 9 | 1762258 | 179027 | 5.585730 | 9843498 | 51 | 30 | 1822355 | 185339 | 5.395517 | 9832549 | 30 | 50 | 1879528 | 191363 | 10 | |
| 10 | 1765121 | 179327 | 5.576378 | 9842985 | 50 | 31 | 1825215 | 185639 | 5.386771 | 9832019 | 29 | 51 | 1882385 | 191664 | 9 | |
| 11 | 1767984 | 179628 | 5.567037 | 9842471 | 49 | 32 | 1828075 | 185940 | 5.378053 | 9831487 | 28 | 52 | 1885241 | 191966 | 8 | |
| 12 | 1770847 | 179928 | 5.557766 | 9841956 | 48 | 33 | 1830935 | 186241 | 5.369363 | 9830955 | 27 | 53 | 1888098 | 192268 | 7 | |
| 13 | 1773710 | 180228 | 5.548505 | 9841441 | 47 | 34 | 1833795 | 186542 | 5.360699 | 9830422 | 26 | 54 | 1890954 | 192569 | 6 | |
| 14 | 1776573 | 180529 | 5.539274 | 9840924 | 46 | 35 | 1836654 | 186843 | 5.352062 | 9829888 | 25 | 55 | 1893811 | 192871 | 5 | |
| 15 | 1779435 | 180829 | 5.530072 | 9840407 | 45 | 36 | 1839514 | 187144 | 5.343452 | 9829353 | 24 | 56 | 1896667 | 193173 | 4 | |
| 16 | 1782298 | 181129 | 5.520900 | 9839889 | 44 | 37 | 1842373 | 187446 | 5.334869 | 9828818 | 23 | 57 | 1899523 | 193474 | 3 | |
| 17 | 1785160 | 181430 | 5.511757 | 9839370 | 43 | 38 | 1845232 | 187747 | 5.326313 | 9828282 | 22 | 58 | 1902379 | 193776 | 2 | |
| 18 | 1788022 | 181730 | 5.502644 | 9838850 | 42 | 39 | 1848091 | 188048 | 5.317783 | 9827744 | 21 | 59 | 1905234 | 194078 | 1 | |
| 19 | 1790884 | 182031 | 5.493560 | 9838330 | 41 | 40 | 1850949 | 188349 | 5.309279 | 9827206 | 20 | 60 | 1908090 | 194380 | 0 | |
| 20 | 1793746 | 182331 | 5.484505 | 9837808 | 40 | | | | | | | | | 5.144554 | 9816272 | 0 |
| ' | Cosine. | Cotan. | Tang. | Sine. | ' | ' | Cosine. | Cotan. | Sine. | ' | ' | Cosine. | Cotan. | Sine. | ' | |
| | | | | | | | | | | | | | | | Deg. 79. | |
| | | | | | | | | | | | | | | | Deg. 79. | |
| | | | | | | | | | | | | | | | Deg. 79. | |

Deg. 79.

Deg. 79.

Deg. 79.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

11 Deg.

11 Deg.

11 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|---|
| 0 | .1908090 | .194380 | 5.144554 | .9816272 | 60 | .21 | .1968018 | .200727 | 4.981881 | .9804433 | 39 | 41 | .2025024 | .206786 | |
| 1 | .1910945 | .194682 | 5.136576 | .9815716 | 59 | 22 | .1970870 | .201030 | 4.974381 | .9803860 | 38 | 42 | .2027873 | .207090 | |
| 2 | .1913801 | .194984 | 5.128622 | .9815160 | 58 | 23 | .1973722 | .201332 | 4.966903 | .9803286 | 37 | 43 | .2030721 | .207393 | |
| 3 | .1916656 | .195286 | 5.120692 | .9814603 | 57 | 24 | .1976573 | .201635 | 4.959447 | .9802712 | 36 | 44 | .2033569 | .207696 | |
| 4 | .1919510 | .195588 | 5.112785 | .9814045 | 56 | 25 | .1979425 | .201938 | 4.952012 | .9802136 | 35 | 45 | .2036418 | .208000 | |
| 5 | .1922365 | .195890 | 5.104902 | .9813486 | 55 | 26 | .1982276 | .202240 | 4.944599 | .9801560 | 34 | 46 | .2039265 | .208303 | |
| 6 | .1925220 | .196192 | 5.097042 | .9812927 | 54 | 27 | .1985127 | .202543 | 4.937206 | .9800983 | 33 | 47 | .2042113 | .208607 | |
| 7 | .1928074 | .196494 | 5.089206 | .9812366 | 53 | 28 | .1987978 | .202846 | 4.929835 | .9800405 | 32 | 48 | .2044961 | .208910 | |
| 8 | .1930928 | .196796 | 5.081392 | .9811805 | 52 | 29 | .1990829 | .203149 | 4.922485 | .9799827 | 31 | 49 | .2047808 | .209214 | |
| 9 | .1933782 | .197098 | 5.073602 | .9811243 | 51 | 30 | .1993679 | .203452 | 4.915157 | .9799247 | 30 | 50 | .2050655 | .209518 | |
| 10 | .1936636 | .197400 | 5.065835 | .9810680 | 50 | 31 | .1996530 | .203755 | 4.907849 | .9798667 | 29 | 51 | .2053502 | .209821 | |
| 11 | .1939490 | .197703 | 5.058090 | .9810116 | 49 | 32 | .1999380 | .204058 | 4.900562 | .9798086 | 28 | 52 | .2056349 | .210125 | |
| 12 | .1942344 | .198005 | 5.050369 | .9809552 | 48 | 33 | .2002230 | .204361 | 4.893295 | .9797504 | 27 | 53 | .2059195 | .210429 | |
| 13 | .1945197 | .198307 | 5.042670 | .9808986 | 47 | 34 | .2005080 | .204664 | 4.886049 | .9796921 | 26 | 54 | .2062042 | .210733 | |
| 14 | .1948050 | .198610 | 5.034993 | .9808420 | 46 | 35 | .2007930 | .204967 | 4.878824 | .9796337 | 25 | 55 | .2064888 | .211036 | |
| 15 | .1950903 | .198912 | 5.027339 | .9807853 | 45 | 36 | .2010779 | .205270 | 4.871620 | .9795752 | 24 | 56 | .2067734 | .211340 | |
| 16 | .1953756 | .199214 | 5.019707 | .9807285 | 44 | 37 | .2013629 | .205573 | 4.864435 | .9795167 | 23 | 57 | .2070580 | .211644 | |
| 17 | .1956609 | .199517 | 5.012098 | .9806716 | 43 | 38 | .2016478 | .205876 | 4.857271 | .9794581 | 22 | 58 | .2073426 | .211948 | |
| 18 | .1959461 | .199819 | 5.004511 | .9806147 | 42 | 39 | .2019327 | .206180 | 4.850128 | .9793994 | 21 | 59 | .2076272 | .212252 | |
| 19 | .1962314 | .200122 | 4.996945 | .9805576 | 41 | 40 | .2022176 | .206483 | 4.843004 | .9793406 | 20 | 60 | .2079117 | .212556 | |
| 20 | .1965166 | .200424 | 4.989402 | .9805005 | 40 | | | | | | | | | | |

Deg. 78.

Deg. 78.

Deg. 78.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

12 Deg.

12 Deg.

12 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ° | Sine. | Tang. | Cotang. | Cosine. | ° | Sine. | Tang. | Cotang. | Cosine. | ° |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----|-------|----------|---------|----------|----------|
| 0 | .2079117 | .212556 | 4.704630 | .9781476 | 60 | .21 | .2138829 | .218949 | 4.567261 | 39 | .41 | .2195624 | .225054 | 4.443376 | .9755985 |
| 1 | .2081962 | .212860 | 4.697910 | .9780871 | 59 | .22 | .2141671 | .219254 | 4.560911 | 38 | .42 | .2198462 | .225359 | 4.437350 | .9755345 |
| 2 | .2084807 | .213164 | 4.691208 | .9780265 | 58 | .23 | .2144512 | .219559 | 4.554577 | 37 | .43 | .2201300 | .225665 | 4.431339 | .9754706 |
| 3 | .2087652 | .213468 | 4.684524 | .9779658 | 57 | .24 | .2147353 | .219864 | 4.548260 | 36 | .44 | .2204137 | .225971 | 4.425343 | .9754065 |
| 4 | .2090497 | .213773 | 4.677859 | .9779050 | 56 | .25 | .2150194 | .220169 | 4.541960 | 35 | .45 | .2206974 | .226276 | 4.419364 | .9753423 |
| 5 | .2093341 | .214077 | 4.671212 | .9778441 | 55 | .26 | .2153035 | .220474 | 4.535677 | 34 | .46 | .2209811 | .226582 | 4.413399 | .9752781 |
| 6 | .2096186 | .214381 | 4.664583 | .9777832 | 54 | .27 | .2155876 | .220779 | 4.529410 | 33 | .47 | .2212648 | .226888 | 4.407450 | .9752138 |
| 7 | .2099030 | .214685 | 4.657972 | .9777222 | 53 | .28 | .2158716 | .221084 | 4.523160 | 32 | .48 | .2215485 | .227194 | 4.401516 | .9751494 |
| 8 | .2101874 | .214990 | 4.651378 | .9776611 | 52 | .29 | .2161556 | .221389 | 4.516926 | 31 | .49 | .2218321 | .227500 | 4.395597 | .9750849 |
| 9 | .2104718 | .215294 | 4.644803 | .9775999 | 51 | .30 | .2164396 | .221694 | 4.510708 | 30 | .50 | .2221158 | .227806 | 4.389694 | .9750203 |
| 10 | .2107561 | .215598 | 4.638245 | .9775386 | 50 | .31 | .2167236 | .221999 | 4.504507 | 29 | .51 | .2223994 | .228112 | 4.383805 | .9749556 |
| 11 | .2110405 | .215903 | 4.631705 | .9774773 | 49 | .32 | .2170076 | .222305 | 4.498322 | 28 | .52 | .2226830 | .228418 | 4.377931 | .9748909 |
| 12 | .2113248 | .216207 | 4.625183 | .9774159 | 48 | .33 | .2172915 | .222610 | 4.492153 | 27 | .53 | .2229666 | .228724 | 4.372073 | .9748261 |
| 13 | .2116091 | .216512 | 4.618678 | .9773544 | 47 | .34 | .2175754 | .222915 | 4.486000 | 26 | .54 | .2232501 | .229030 | 4.366229 | .9747612 |
| 14 | .2118934 | .216816 | 4.612190 | .9772928 | 46 | .35 | .2178593 | .223221 | 4.479863 | 25 | .55 | .2235337 | .229336 | 4.360400 | .9746962 |
| 15 | .2121777 | .217121 | 4.605720 | .9772311 | 45 | .36 | .2181432 | .223526 | 4.473742 | 24 | .56 | .2238172 | .229642 | 4.354586 | .9746311 |
| 16 | .2124619 | .217425 | 4.599268 | .9771693 | 44 | .37 | .2184271 | .223831 | 4.467637 | 23 | .57 | .2241007 | .229949 | 4.348786 | .9745660 |
| 17 | .2127462 | .217730 | 4.592832 | .9771075 | 43 | .38 | .2187110 | .224137 | 4.461548 | 22 | .58 | .2243842 | .230255 | 4.343001 | .9745008 |
| 18 | .2130304 | .218035 | 4.586414 | .9770456 | 42 | .39 | .2189948 | .224442 | 4.455475 | 21 | .59 | .2246676 | .230561 | 4.337231 | .9744355 |
| 19 | .2133146 | .218340 | 4.580012 | .9769836 | 41 | .40 | .2192786 | .224748 | 4.449418 | 20 | .60 | .2249511 | .230868 | 4.331475 | .9743701 |
| 20 | .2135988 | .218644 | 4.573628 | .9769215 | 40 | | | | | | | | | | |

Deg. 77.

Deg. 77.

Deg. 77.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

13 Deg.

13 Deg.

13 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ° | ° | Sine. | Tang. | Cotang. | Cosine. | ° | ° | Sine. | Tang. | Cotang. | Cosine. | ° |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .2249511 | .230868 | 4.331475 | .9743701 | 60 | 21 | .2308989 | .237311 | 4.213869 | .9729777 | 39 | 41 | .2365555 | .243465 | 4.107356 | .9716180 | 19 |
| 1 | .2252345 | .231174 | 4.325734 | .9743046 | 59 | 22 | .2311819 | .237618 | 4.208419 | .9729105 | 38 | 42 | .2368381 | .243773 | 4.102164 | .9715491 | 18 |
| 2 | .2255179 | .231481 | 4.320007 | .9742390 | 58 | 23 | .2314649 | .237926 | 4.202983 | .9728432 | 37 | 43 | .2371207 | .244081 | 4.096985 | .9714802 | 17 |
| 3 | .2258013 | .231787 | 4.314295 | .9741734 | 57 | 24 | .2317479 | .238233 | 4.197560 | .9727759 | 36 | 44 | .2374033 | .244390 | 4.091817 | .9714112 | 16 |
| 4 | .2260846 | .232094 | 4.308597 | .9741077 | 56 | 25 | .2320309 | .238541 | 4.192151 | .9727084 | 35 | 45 | .2376859 | .244698 | 4.086662 | .9713421 | 15 |
| 5 | .2263680 | .232400 | 4.302913 | .9740419 | 55 | 26 | .2323138 | .238848 | 4.186754 | .9726409 | 34 | 46 | .2379684 | .245006 | 4.081519 | .9712729 | 14 |
| 6 | .2266513 | .232707 | 4.297244 | .9739760 | 54 | 27 | .2325967 | .239156 | 4.181371 | .9725733 | 33 | 47 | .2382510 | .245315 | 4.076389 | .9712036 | 13 |
| 7 | .2269346 | .233014 | 4.291588 | .9739100 | 53 | 28 | .2328796 | .239463 | 4.176001 | .9725056 | 32 | 48 | .2385335 | .245623 | 4.071270 | .9711343 | 12 |
| 8 | .2272179 | .233320 | 4.285947 | .9738439 | 52 | 29 | .2331625 | .239771 | 4.170644 | .9724378 | 31 | 49 | .2388159 | .245932 | 4.066164 | .9710649 | 11 |
| 9 | .2275012 | .233627 | 4.280319 | .9737778 | 51 | 30 | .2334454 | .240078 | 4.165299 | .9723699 | 30 | 50 | .2390984 | .246240 | 4.061070 | .9709953 | 10 |
| 10 | .2277844 | .233934 | 4.274706 | .9737116 | 50 | 31 | .2337282 | .240386 | 4.159968 | .9723020 | 29 | 51 | .2393808 | .246549 | 4.055987 | .9709258 | 9 |
| 11 | .2280677 | .234241 | 4.269107 | .9736453 | 49 | 32 | .2340110 | .240694 | 4.154650 | .9722339 | 28 | 52 | .2396633 | .246857 | 4.050917 | .9708561 | 8 |
| 12 | .2283509 | .234547 | 4.263521 | .9735789 | 48 | 33 | .2342938 | .241001 | 4.149344 | .9721658 | 27 | 53 | .2399457 | .247166 | 4.045859 | .9707863 | 7 |
| 13 | .2286341 | .234854 | 4.257950 | .9735124 | 47 | 34 | .2345766 | .241309 | 4.144051 | .9720976 | 26 | 54 | .2402280 | .247475 | 4.040812 | .9707165 | 6 |
| 14 | .2289172 | .235161 | 4.252392 | .9734458 | 46 | 35 | .2348594 | .241617 | 4.138771 | .9720294 | 25 | 55 | .2405104 | .247783 | 4.035777 | .9706466 | 5 |
| 15 | .2292004 | .235468 | 4.246848 | .9733792 | 45 | 36 | .2351421 | .241925 | 4.133504 | .9719610 | 24 | 56 | .2407927 | .248092 | 4.030755 | .9705766 | 4 |
| 16 | .2294835 | .235775 | 4.241317 | .9733125 | 44 | 37 | .2354248 | .242233 | 4.128249 | .9718926 | 23 | 57 | .2410751 | .248401 | 4.025744 | .9705065 | 3 |
| 17 | .2297666 | .236082 | 4.235800 | .9732457 | 43 | 38 | .2357075 | .242541 | 4.123007 | .9718240 | 22 | 58 | .2413574 | .248710 | 4.020744 | .9704363 | 2 |
| 18 | .2300497 | .236390 | 4.230297 | .9731789 | 42 | 39 | .2359902 | .242849 | 4.117778 | .9717554 | 21 | 59 | .2416396 | .249019 | 4.015757 | .9703660 | 1 |
| 19 | .2303328 | .236697 | 4.224808 | .9731119 | 41 | 40 | .2362729 | .243157 | 4.112561 | .9716867 | 20 | 60 | .2419219 | .249328 | 4.010780 | .9702957 | 0 |
| 20 | .2306159 | .237004 | 4.219331 | .9730449 | 40 | | | | | | | | | | | | |

Deg. 76.

Deg. 76.

Deg. 76.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 14 Deg. | | | | 14 Deg. | | | | 14 Deg. | | | | 14 Deg. | | | | | |
|---------|----------|--------|-----------|---------|---------|----|---------|---------|---------|---------|---------|---------|---------|--------|---------|---------|---------|
| ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. | ° | ' | Sine. | Tang. | Cotang. | Cosine. |
| 0 | 2419219 | 249328 | 4°10'780 | 9702957 | 60 | 21 | 2478445 | 255826 | 3908901 | 9687998 | 39 | 41 | 2534766 | 262034 | 3816295 | 9673415 | 19 |
| 1 | 24222041 | 249637 | 4°00'816 | 9702253 | 59 | 22 | 2481263 | 256136 | 3904171 | 9687277 | 38 | 42 | 2537579 | 262345 | 3811773 | 9672678 | 18 |
| 2 | 2424863 | 249964 | 4°00'863 | 9701548 | 58 | 23 | 2484108 | 256446 | 3899451 | 9686555 | 37 | 43 | 2540393 | 262656 | 3807260 | 9671939 | 17 |
| 3 | 2427685 | 250255 | 3°95'922 | 9700842 | 57 | 24 | 2486899 | 256756 | 3894742 | 9685832 | 36 | 44 | 2543206 | 262967 | 3802758 | 9671200 | 16 |
| 4 | 2430507 | 250504 | 3°96'092 | 9700135 | 56 | 25 | 2489716 | 257066 | 3890044 | 9685108 | 35 | 45 | 2546019 | 263278 | 3798266 | 9670459 | 15 |
| 5 | 2433329 | 250873 | 3°96'073 | 9699428 | 55 | 26 | 2492533 | 257376 | 3885357 | 9684383 | 34 | 46 | 2548832 | 263589 | 3793783 | 9669718 | 14 |
| 6 | 2436150 | 251182 | 3°96'166 | 9698720 | 54 | 27 | 2495350 | 257686 | 3880680 | 9683658 | 33 | 47 | 2551645 | 263900 | 3789310 | 9668977 | 13 |
| 7 | 2438971 | 251491 | 3°97'621 | 9698011 | 53 | 28 | 2498167 | 257997 | 3876014 | 9682931 | 32 | 48 | 2554458 | 264211 | 3785484 | 9668234 | 12 |
| 8 | 2441792 | 251801 | 3°97'136 | 9697301 | 52 | 29 | 2500984 | 258307 | 3871358 | 9682204 | 31 | 49 | 2557270 | 264522 | 3780395 | 9667490 | 11 |
| 9 | 2444613 | 252110 | 3°96'653 | 9696591 | 51 | 30 | 2503800 | 258617 | 3866718 | 9681476 | 30 | 50 | 2560082 | 264833 | 3775951 | 9666746 | 10 |
| 10 | 2447433 | 252420 | 3°96'161 | 9695879 | 50 | 31 | 2506616 | 258928 | 3862078 | 9680748 | 29 | 51 | 2562894 | 265144 | 3771518 | 9666001 | 9 |
| 11 | 2450254 | 252729 | 3°96'6801 | 9695167 | 49 | 32 | 2509432 | 259238 | 3857453 | 9680018 | 28 | 52 | 2565705 | 265456 | 3767094 | 9665255 | 8 |
| 12 | 2453074 | 253038 | 3°96'1901 | 9694453 | 48 | 33 | 2512248 | 259548 | 3852839 | 9679288 | 27 | 53 | 2568517 | 265768 | 3762680 | 9664508 | 7 |
| 13 | 2455894 | 253348 | 3°94'713 | 9693740 | 47 | 34 | 2515063 | 259859 | 3848235 | 9678557 | 26 | 54 | 2571328 | 266079 | 3758276 | 9663761 | 6 |
| 14 | 2458713 | 253658 | 3°94'2315 | 9693025 | 46 | 35 | 2517879 | 260169 | 3843642 | 9677825 | 25 | 55 | 2574139 | 266390 | 3753881 | 9663012 | 5 |
| 15 | 2461533 | 253967 | 3°93'7509 | 9692309 | 45 | 36 | 2520694 | 260480 | 3839486 | 9677092 | 24 | 56 | 2576950 | 266702 | 3749496 | 9662263 | 4 |
| 16 | 2464352 | 254277 | 3°93'2714 | 9691593 | 44 | 37 | 2523508 | 260791 | 3834939 | 9676358 | 23 | 57 | 2579760 | 267013 | 3745120 | 9661513 | 3 |
| 17 | 2467171 | 254587 | 3°92'7929 | 9690875 | 43 | 38 | 2526323 | 261101 | 3829973 | 9675624 | 22 | 58 | 2582570 | 267325 | 3740754 | 9660762 | 2 |
| 18 | 2469990 | 254896 | 3°92'3156 | 9690157 | 42 | 39 | 2529137 | 261412 | 3825372 | 9674888 | 21 | 59 | 2585381 | 267637 | 3736398 | 9660011 | 1 |
| 19 | 2472809 | 255206 | 3°91'8393 | 9689438 | 41 | 40 | 2531952 | 261723 | 3820828 | 9674152 | 20 | 60 | 2588190 | 267949 | 3732050 | 9659258 | 0 |
| 20 | 2475627 | 255516 | 3°91'3642 | 9688719 | 40 | | | | | | | | | | | | |

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 15 Deg. | | | | | | | | | | 15 Deg. | | | | | | | | | | Deg. 74. | | | | | | | | | |
|---------|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|---|-------|----------|---------|---------|---|---|-------|-------|---------|---------|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
| 0 | 2581890 | 267949 | 3732050 | 9659258 | 60 | 21 | 2647147 | 274507 | 3642891 | 9643268 | 39 | 41 | 2703204 | 280773 | 3561590 | 9627704 | 19 | | | | | | | | | | | | |
| 1 | 2591000 | 268261 | 3727713 | 9658505 | 59 | 22 | 2649952 | 274820 | 3638744 | 9642497 | 38 | 42 | 2706004 | 281087 | 3557613 | 9626917 | 18 | | | | | | | | | | | | |
| 2 | 2593810 | 268572 | 3723384 | 9657751 | 58 | 23 | 2652757 | 275133 | 3634606 | 9641726 | 37 | 43 | 2708805 | 281401 | 3553644 | 9626130 | 17 | | | | | | | | | | | | |
| 3 | 2596619 | 268884 | 3719065 | 9656996 | 57 | 24 | 2655561 | 275445 | 3630477 | 9640954 | 36 | 44 | 2711605 | 281715 | 3549684 | 9625342 | 16 | | | | | | | | | | | | |
| 4 | 2599428 | 269196 | 3714756 | 9656240 | 56 | 25 | 2658366 | 275758 | 3626356 | 9640181 | 35 | 45 | 2714704 | 282029 | 3545732 | 9624552 | 15 | | | | | | | | | | | | |
| 5 | 2602237 | 269508 | 3710455 | 9655484 | 55 | 26 | 2661170 | 276071 | 3622244 | 9639407 | 34 | 46 | 2717204 | 282343 | 3541788 | 9623762 | 14 | | | | | | | | | | | | |
| 6 | 2605045 | 269820 | 3706164 | 9654726 | 54 | 27 | 2663973 | 276385 | 3618141 | 9638633 | 33 | 47 | 2720003 | 282657 | 3537852 | 9622972 | 13 | | | | | | | | | | | | |
| 7 | 2607853 | 270132 | 3701883 | 9653968 | 53 | 28 | 2666777 | 276698 | 3614046 | 9637858 | 32 | 48 | 2722802 | 282971 | 3533925 | 9622180 | 12 | | | | | | | | | | | | |
| 8 | 2610662 | 270444 | 3697610 | 9653209 | 52 | 29 | 2669581 | 277011 | 3609960 | 9637081 | 31 | 49 | 2725601 | 283285 | 3530005 | 9621387 | 11 | | | | | | | | | | | | |
| 9 | 2613469 | 270757 | 3693346 | 9652449 | 51 | 30 | 2672384 | 277324 | 3605883 | 9636305 | 30 | 50 | 2728400 | 283599 | 3526093 | 9620594 | 10 | | | | | | | | | | | | |
| 10 | 2616277 | 271069 | 3689092 | 9651689 | 50 | 31 | 2675187 | 277637 | 3601814 | 9635527 | 29 | 51 | 2731198 | 283914 | 3522190 | 9619800 | 9 | | | | | | | | | | | | |
| 11 | 2619085 | 271381 | 3684847 | 9650927 | 49 | 32 | 2677989 | 277951 | 3597754 | 9634748 | 28 | 52 | 2733997 | 284228 | 3518294 | 9619005 | 8 | | | | | | | | | | | | |
| 12 | 2621892 | 271694 | 3680611 | 9650165 | 48 | 33 | 2680792 | 278264 | 3593702 | 9633969 | 27 | 53 | 2736794 | 284543 | 3514407 | 9618210 | 7 | | | | | | | | | | | | |
| 13 | 2624699 | 272006 | 3676384 | 9649402 | 47 | 34 | 2683594 | 278578 | 3589659 | 9633189 | 26 | 54 | 2739592 | 284857 | 3510527 | 9617413 | 6 | | | | | | | | | | | | |
| 14 | 2627506 | 272318 | 3672166 | 9648638 | 46 | 35 | 2686396 | 278891 | 3585624 | 9632408 | 25 | 55 | 2742390 | 285172 | 3506655 | 9616616 | 5 | | | | | | | | | | | | |
| 15 | 2630312 | 272631 | 3667957 | 9647873 | 45 | 36 | 2689198 | 279205 | 3581597 | 9631626 | 24 | 56 | 2745187 | 285486 | 3502791 | 9615818 | 4 | | | | | | | | | | | | |
| 16 | 2633118 | 272943 | 3663757 | 9647108 | 44 | 37 | 2692000 | 279518 | 3577579 | 9630843 | 23 | 57 | 2747984 | 285801 | 3498935 | 9615019 | 3 | | | | | | | | | | | | |
| 17 | 2635925 | 273256 | 3659566 | 9646341 | 43 | 38 | 2694801 | 279832 | 3573569 | 9630060 | 22 | 58 | 2750781 | 286115 | 3495087 | 9614219 | 2 | | | | | | | | | | | | |
| 18 | 2638730 | 273569 | 3655384 | 9645574 | 42 | 39 | 2697602 | 280145 | 3569568 | 9629275 | 21 | 59 | 2753577 | 286430 | 3491247 | 9613418 | 1 | | | | | | | | | | | | |
| 19 | 2641536 | 273881 | 3651211 | 9644806 | 41 | 40 | 2700403 | 280459 | 3565574 | 9628490 | 20 | 60 | 2756374 | 286745 | 3487414 | 9612617 | 0 | | | | | | | | | | | | |
| 20 | 2644342 | 274194 | 3547046 | 9644037 | 40 | | | | | | | | | | | | | | | | | | | | | | | | |

Deg. 74.

Deg. 74.

Deg. 74.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

16 Deg.

16 Deg.

16 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|
| 0 | 2756374 | 286745 | 3487414 | 9612617 | 60 | 21 | 2815042 | 293368 | 3408688 | 9595600 | 39 | 41 | 2870819 | 299697 | 3356699 | 9579060 | 19 |
| 1 | 2759170 | 287060 | 3483589 | 9611815 | 59 | 22 | 2817833 | 293683 | 3405021 | 9594781 | 38 | 42 | 2873605 | 300014 | 3333173 | 9578225 | 18 |
| 2 | 2761965 | 287375 | 3479772 | 9611012 | 58 | 23 | 2820624 | 293999 | 3401361 | 9593961 | 37 | 43 | 2876391 | 300331 | 3329654 | 9577389 | 17 |
| 3 | 2764761 | 287690 | 3475963 | 9610208 | 57 | 24 | 2823415 | 294316 | 3397708 | 9593140 | 36 | 44 | 2879177 | 300648 | 3326141 | 9576552 | 16 |
| 4 | 2767556 | 288005 | 3472161 | 9609403 | 56 | 25 | 2826205 | 294632 | 3394063 | 9592318 | 35 | 45 | 2881963 | 300965 | 3322836 | 9575714 | 15 |
| 5 | 2770352 | 288320 | 3468367 | 9608598 | 55 | 26 | 2828995 | 294948 | 3390424 | 9591496 | 34 | 46 | 2884748 | 301283 | 3319137 | 9574875 | 14 |
| 6 | 2773147 | 288635 | 3464581 | 9607792 | 54 | 27 | 2831785 | 295264 | 3386793 | 9590672 | 33 | 47 | 2887533 | 301600 | 3315645 | 9574035 | 13 |
| 7 | 2775941 | 288950 | 3460802 | 9606984 | 53 | 28 | 2834575 | 295580 | 3383169 | 9589848 | 32 | 48 | 2890318 | 301917 | 3312159 | 9573195 | 12 |
| 8 | 2778736 | 289265 | 3457031 | 9606177 | 52 | 29 | 2837364 | 295897 | 3379553 | 9589023 | 31 | 49 | 2893103 | 302235 | 3308681 | 9572354 | 11 |
| 9 | 2781530 | 289580 | 3453267 | 9605368 | 51 | 30 | 2840153 | 296213 | 3375943 | 9588197 | 30 | 50 | 2895887 | 302552 | 3305209 | 9571512 | 10 |
| 10 | 2784324 | 289896 | 3449512 | 9604558 | 50 | 31 | 2842942 | 296529 | 3372340 | 9587371 | 29 | 51 | 2898671 | 302870 | 3301743 | 9570669 | 9 |
| 11 | 2787118 | 290211 | 3445763 | 9603748 | 49 | 32 | 2845731 | 296846 | 3368745 | 9586543 | 28 | 52 | 2901455 | 303187 | 3298285 | 9569825 | 8 |
| 12 | 2789911 | 290526 | 3442022 | 9602937 | 48 | 33 | 2848520 | 297163 | 3365156 | 9585715 | 27 | 53 | 2904239 | 303505 | 3294833 | 9568981 | 7 |
| 13 | 2792704 | 290842 | 3438289 | 9602125 | 47 | 34 | 2851308 | 297479 | 3361575 | 9584886 | 26 | 54 | 2907022 | 303823 | 3291387 | 9568136 | 6 |
| 14 | 2795497 | 291157 | 3434563 | 9601312 | 46 | 35 | 2854096 | 297796 | 3358000 | 9584056 | 25 | 55 | 2909805 | 304141 | 3287948 | 9567290 | 5 |
| 15 | 2798290 | 291473 | 3430844 | 9600499 | 45 | 36 | 2856884 | 298112 | 3354433 | 9583226 | 24 | 56 | 2912588 | 304458 | 3284516 | 9566443 | 4 |
| 16 | 2801083 | 291789 | 3427133 | 9599684 | 44 | 37 | 2859671 | 298429 | 3350872 | 9582394 | 23 | 57 | 2915371 | 304776 | 3281090 | 9565595 | 3 |
| 17 | 2803875 | 292104 | 3423429 | 9598869 | 43 | 38 | 2862458 | 298746 | 3347319 | 9581562 | 22 | 58 | 2918153 | 305094 | 3277671 | 9564747 | 2 |
| 18 | 2806667 | 292420 | 3419733 | 9598053 | 42 | 39 | 2865246 | 299063 | 3343772 | 9580729 | 21 | 59 | 2920935 | 305412 | 3274258 | 9563898 | 1 |
| 19 | 2809459 | 292736 | 3416044 | 9597236 | 41 | 40 | 2868032 | 299380 | 3340232 | 9579895 | 20 | 60 | 2923717 | 305730 | 3270852 | 9563048 | 0 |
| 20 | 2812251 | 293052 | 3412362 | 9596418 | 40 | | | | | | | | | | | | |

Deg. 73.

Deg. 73.

Deg. 73.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

17 Deg.

| 17 Deg. | | 17 Deg. | | 17 Deg. | | 17 Deg. | | 17 Deg. | | 17 Deg. | | 17 Deg. | |
|---------|---------|---------|---------|---------|----|---------|---------|---------|---------|---------|-------|---------|---------|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. |
| 0 | 2923717 | 305730 | 3270852 | 9563048 | 60 | 21 | 2982079 | 312422 | 3200789 | 9545009 | 39 | 41 | 3037559 |
| 1 | 2926499 | 306048 | 3267452 | 9562197 | 59 | 22 | 2984856 | 312742 | 3197521 | 9544141 | 38 | 42 | 3040331 |
| 2 | 2929280 | 306367 | 3264059 | 9561345 | 58 | 23 | 2987632 | 313061 | 3194259 | 9543273 | 37 | 43 | 3043102 |
| 3 | 2932061 | 306685 | 3260672 | 9560492 | 57 | 24 | 2990408 | 313381 | 3191003 | 9542403 | 36 | 44 | 3045872 |
| 4 | 2934842 | 307003 | 3257292 | 9559639 | 56 | 25 | 2993184 | 313700 | 3187754 | 9541533 | 35 | 45 | 3048643 |
| 5 | 2937623 | 307321 | 3253918 | 9558785 | 55 | 26 | 2995959 | 314020 | 3184510 | 9540662 | 34 | 46 | 3051413 |
| 6 | 2940403 | 307640 | 3250550 | 9557930 | 54 | 27 | 2998734 | 314339 | 3181272 | 9539790 | 33 | 47 | 3054183 |
| 7 | 2943183 | 307958 | 3247189 | 9557074 | 53 | 28 | 3001509 | 314659 | 3178040 | 9538917 | 32 | 48 | 3056953 |
| 8 | 2945963 | 308277 | 3243834 | 9556218 | 52 | 29 | 3004284 | 314979 | 3174814 | 9538044 | 31 | 49 | 3059723 |
| 9 | 2948743 | 308595 | 3240486 | 9555361 | 51 | 30 | 3007058 | 315298 | 3171594 | 9537170 | 30 | 50 | 3062492 |
| 10 | 2951522 | 308914 | 3237143 | 9554502 | 50 | 31 | 3009832 | 315618 | 3168380 | 9536294 | 29 | 51 | 3065261 |
| 11 | 2954302 | 309233 | 3233807 | 9553643 | 49 | 32 | 3012606 | 315938 | 3165172 | 9535418 | 28 | 52 | 3068030 |
| 12 | 2957081 | 309551 | 3230478 | 9552784 | 48 | 33 | 3015380 | 316258 | 3161970 | 9534542 | 27 | 53 | 3070798 |
| 13 | 2959859 | 309870 | 3227154 | 9551923 | 47 | 34 | 3018153 | 316578 | 3158774 | 9533664 | 26 | 54 | 3073566 |
| 14 | 2962638 | 310189 | 3223837 | 9551062 | 46 | 35 | 3020926 | 316898 | 3155584 | 9532786 | 25 | 55 | 3076334 |
| 15 | 2965416 | 310508 | 3220526 | 9550199 | 45 | 36 | 3023699 | 317218 | 3152399 | 9531907 | 24 | 56 | 3079102 |
| 16 | 2968194 | 310827 | 3217221 | 9549336 | 44 | 37 | 3026471 | 317538 | 3149220 | 9531027 | 23 | 57 | 3081869 |
| 17 | 2970971 | 311146 | 3213922 | 9548473 | 43 | 38 | 3029244 | 317859 | 3146047 | 9530146 | 22 | 58 | 3084636 |
| 18 | 2973749 | 311465 | 3210630 | 9547608 | 42 | 39 | 3032016 | 318179 | 3142880 | 9529264 | 21 | 59 | 3087403 |
| 19 | 2976526 | 311784 | 3207344 | 9546743 | 41 | 40 | 3034788 | 318499 | 3139719 | 9528382 | 20 | 60 | 3090170 |
| 20 | 2979303 | 312103 | 3204063 | 9545876 | 40 | | | | | | | | |

Deg. 72.

Deg. 72.

Deg. 72.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 18 Deg. | | | | 18 Deg. | | | | 18 Deg. | | | | 18 Deg. | | | | | | | |
|---------|----------|--------|-----------|----------|----|-------|----------|----------|----------|----------|-------|---------|----------|---------|----------|----------|-------|---------|---------|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. |
| 0 | ·3090170 | 324919 | 3·077693 | ·9500565 | 60 | 21 | ·3148209 | ·331686 | 3·014892 | ·9491511 | 39 | 41 | ·3203374 | 338157 | 2·957205 | ·9473085 | 19 | | |
| 1 | ·3092936 | 325241 | 3·0774640 | ·9509666 | 59 | 22 | ·3150969 | ·3320093 | 3·011960 | ·9490595 | 38 | 42 | ·3206130 | 338481 | 2·954372 | ·9472103 | 18 | | |
| 2 | ·3095702 | 325563 | 3·0771602 | ·9518766 | 58 | 23 | ·3153730 | ·3323332 | 3·009033 | ·9489678 | 37 | 43 | ·3208885 | 338805 | 2·951545 | ·9471170 | 17 | | |
| 3 | ·3098468 | 325884 | 3·0868569 | ·9507865 | 57 | 24 | ·3156490 | ·332655 | 3·006110 | ·9488760 | 36 | 44 | ·3211640 | 339129 | 2·948722 | ·9470236 | 16 | | |
| 4 | ·3101234 | 326206 | 3·065542 | ·9506961 | 56 | 25 | ·3159250 | ·332978 | 3·003193 | ·9487842 | 35 | 45 | ·3214395 | 339454 | 2·945905 | ·9469301 | 15 | | |
| 5 | ·3103999 | 326528 | 3·062520 | ·9506061 | 55 | 26 | ·3162010 | ·333302 | 3·000282 | ·9486922 | 34 | 46 | ·3217149 | 339778 | 2·943092 | ·9468366 | 14 | | |
| 6 | ·3106764 | 326850 | 3·059503 | ·9505157 | 54 | 27 | ·3164779 | ·333625 | 2·997375 | ·9486002 | 33 | 47 | ·3219903 | 340103 | 2·940284 | ·9467430 | 13 | | |
| 7 | ·3109529 | 327172 | 3·056492 | ·9504253 | 53 | 28 | ·3167529 | ·333948 | 2·994473 | ·9485081 | 32 | 48 | ·3222657 | 340427 | 2·937480 | ·9466493 | 12 | | |
| 8 | ·3112294 | 327494 | 3·053487 | ·9503348 | 52 | 29 | ·3170288 | ·334271 | 2·991576 | ·9484159 | 31 | 49 | ·3225411 | 340752 | 2·934682 | ·9465551 | 11 | | |
| 9 | ·3115058 | 327816 | 3·050436 | ·9502443 | 51 | 30 | ·3173047 | ·334595 | 2·988685 | ·9483232 | 30 | 50 | ·3228164 | 341077 | 2·931988 | ·9464616 | 10 | | |
| 10 | ·3117822 | 328138 | 3·047491 | ·9501536 | 50 | 31 | ·3175805 | ·334918 | 2·985798 | ·9482313 | 29 | 51 | ·3230917 | 341401 | 2·929099 | ·9463677 | 9 | | |
| 11 | ·3120586 | 328461 | 3·044501 | ·9500629 | 49 | 32 | ·3178563 | ·335242 | 2·982916 | ·9481389 | 28 | 52 | ·3233670 | 341726 | 2·926315 | ·9462736 | 8 | | |
| 12 | ·3123349 | 328783 | 3·041517 | ·9499721 | 48 | 33 | ·3181321 | ·335566 | 2·980040 | ·9480464 | 27 | 53 | ·3236422 | 342051 | 2·923635 | ·9461795 | 7 | | |
| 13 | ·3126112 | 329105 | 3·038538 | ·9498812 | 47 | 34 | ·3184079 | ·335889 | 2·977168 | ·9479538 | 26 | 54 | ·3239174 | 342376 | 2·920761 | ·9460854 | 6 | | |
| 14 | ·3128875 | 329428 | 3·035564 | ·9497902 | 46 | 35 | ·3186836 | ·336213 | 2·974301 | ·9478612 | 25 | 55 | ·3241926 | 342701 | 2·917990 | ·9459911 | 5 | | |
| 15 | ·3131638 | 329750 | 3·032595 | ·9496991 | 45 | 36 | ·3189593 | ·336537 | 2·971439 | ·9477684 | 24 | 56 | ·3244678 | 343026 | 2·915225 | ·9458968 | 4 | | |
| 16 | ·3134400 | 330073 | 3·029592 | ·9496080 | 44 | 37 | ·3192350 | ·336861 | 2·968583 | ·9476756 | 23 | 57 | ·3247429 | 343351 | 2·912464 | ·9458023 | 3 | | |
| 17 | ·3137163 | 330395 | 3·026673 | ·9495168 | 43 | 38 | ·3195106 | ·337185 | 2·965731 | ·9475827 | 22 | 58 | ·3250180 | 343677 | 2·909708 | ·9457078 | 2 | | |
| 18 | ·3139925 | 330718 | 3·023720 | ·9494255 | 42 | 39 | ·3197863 | ·337509 | 2·962884 | ·9474897 | 21 | 59 | ·3252931 | 344002 | 2·906957 | ·9456132 | 1 | | |
| 19 | ·3142686 | 331041 | 3·020772 | ·9493341 | 41 | 40 | ·3200619 | ·337833 | 2·960094 | ·9473966 | 20 | 60 | ·3255682 | 344327 | 2·904211 | ·9455186 | 0 | | |
| 20 | ·3145448 | 331363 | 3·017830 | ·9492426 | 40 | | | | | | | | | | | | | | |

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

19 Deg.

19 Deg.

19 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|---------|---------|----|---------|---------|---------|---------|----|---------|---------|---------|---------|---------|
| 0 | 3255682 | 344327 | 2904210 | 9455186 | 60 | 21 | 3313379 | 331175 | 2847583 | 39 | 41 | 3368214 | 357723 | 2795453 | 9415686 |
| 1 | 3258432 | 344653 | 2901468 | 9454238 | 59 | 22 | 3316123 | 331501 | 2844935 | 38 | 42 | 3370953 | 358051 | 2792891 | 9414705 |
| 2 | 3261182 | 344978 | 2898731 | 9453290 | 58 | 23 | 3318867 | 331828 | 2842292 | 37 | 43 | 3373691 | 358380 | 2790333 | 9413724 |
| 3 | 3263932 | 345304 | 2895998 | 9452341 | 57 | 24 | 3321611 | 332155 | 2839653 | 36 | 44 | 3376429 | 358708 | 2787780 | 9412743 |
| 4 | 3266681 | 345629 | 2893270 | 9451391 | 56 | 25 | 3324355 | 332482 | 2837019 | 35 | 45 | 3379167 | 359036 | 2785230 | 9411760 |
| 5 | 3269430 | 345955 | 2890546 | 9450441 | 55 | 26 | 3327098 | 332809 | 2834389 | 34 | 46 | 3381905 | 359365 | 2782685 | 9410777 |
| 6 | 3272179 | 346281 | 2887827 | 9449489 | 54 | 27 | 3329841 | 333136 | 2831763 | 33 | 47 | 3384642 | 359693 | 2780144 | 9409793 |
| 7 | 3274928 | 346606 | 2885113 | 9448537 | 53 | 28 | 3332584 | 333464 | 2829142 | 32 | 48 | 3387379 | 360022 | 2777606 | 9408808 |
| 8 | 3277676 | 346932 | 2882403 | 9447584 | 52 | 29 | 3335326 | 333791 | 2826525 | 31 | 49 | 3390116 | 360350 | 2775073 | 9407822 |
| 9 | 3280424 | 347258 | 2879697 | 9446630 | 51 | 30 | 3338069 | 334118 | 2823912 | 30 | 50 | 3392852 | 360679 | 2772544 | 9406835 |
| 10 | 3283172 | 347584 | 2876997 | 9445675 | 50 | 31 | 3340810 | 334446 | 2821304 | 29 | 51 | 3395589 | 361008 | 2770019 | 9405848 |
| 11 | 3285919 | 347910 | 2874300 | 9444720 | 49 | 32 | 3343552 | 334773 | 2818700 | 28 | 52 | 3398325 | 361337 | 2767499 | 9404860 |
| 12 | 3288666 | 348236 | 2871608 | 9443764 | 48 | 33 | 3346293 | 335101 | 2816100 | 27 | 53 | 3401060 | 361666 | 2764982 | 9403871 |
| 13 | 3291413 | 348563 | 2868921 | 9442807 | 47 | 34 | 3349034 | 335428 | 2813504 | 26 | 54 | 3403796 | 361994 | 2762469 | 9402881 |
| 14 | 3294160 | 348889 | 2866238 | 9441849 | 46 | 35 | 3351775 | 335756 | 2810913 | 25 | 55 | 3406531 | 362324 | 2759960 | 9401891 |
| 15 | 3296906 | 349215 | 2863560 | 9440890 | 45 | 36 | 3354516 | 336084 | 2808326 | 24 | 56 | 3409265 | 362653 | 2757456 | 9400899 |
| 16 | 3299653 | 349542 | 2860886 | 9439931 | 44 | 37 | 3357256 | 336411 | 2805743 | 23 | 57 | 3412000 | 362982 | 2754955 | 9399907 |
| 17 | 3302398 | 349868 | 2858212 | 9438971 | 43 | 38 | 3359996 | 336739 | 2803164 | 22 | 58 | 3414734 | 363311 | 2752458 | 9398914 |
| 18 | 3305144 | 350195 | 2855551 | 9438010 | 42 | 39 | 3362735 | 337067 | 2800590 | 21 | 59 | 3417468 | 363640 | 2749966 | 9397921 |
| 19 | 3307889 | 350521 | 2852891 | 9437048 | 41 | 40 | 3365475 | 337395 | 2798019 | 20 | 60 | 3420201 | 363970 | 2747477 | 9396925 |
| 20 | 3310634 | 350848 | 2850234 | 9436085 | 40 | | | | | | | | | | |
| ' | Cosine. | Cotan. | Tang. | Sine. | ' | Cosine. | Cotan. | Tang. | Sine. | ' | Cosine. | Cotan. | Tang. | Sine. | ' |

Deg. 70.

Deg. 70.

Deg. 70.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

20 Deg.

20 Deg.

20 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|---------|---------|----|-------|---------|---------|---------|----|-------|---------|---------|---------|---------|
| 0 | 3420201 | 363970 | 2747477 | 9396926 | 60 | 21 | 3477540 | 370903 | 2696118 | 39 | 41 | 3532027 | 377536 | 2648753 | 9355408 |
| 1 | 3422935 | 364299 | 2744992 | 9395931 | 59 | 22 | 3480267 | 371234 | 2693714 | 38 | 42 | 3534748 | 377868 | 2646423 | 9354440 |
| 2 | 3425668 | 364629 | 2742512 | 9394935 | 58 | 23 | 3482994 | 371565 | 2691314 | 37 | 43 | 3537469 | 378201 | 2644096 | 9353412 |
| 3 | 3428400 | 364958 | 2740035 | 9393938 | 57 | 24 | 3485720 | 371896 | 2688919 | 36 | 44 | 3540190 | 378533 | 2641774 | 9352382 |
| 4 | 3431133 | 365288 | 2737562 | 9392940 | 56 | 25 | 3488447 | 372227 | 2686526 | 35 | 45 | 3542910 | 378866 | 2639454 | 9351352 |
| 5 | 3433865 | 365618 | 2735093 | 9391942 | 55 | 26 | 3491173 | 372559 | 2684138 | 34 | 46 | 3545630 | 379198 | 2637139 | 9350321 |
| 6 | 3436597 | 365948 | 2732628 | 9390943 | 54 | 27 | 3493898 | 372890 | 2681753 | 33 | 47 | 3548350 | 379531 | 2634827 | 9349289 |
| 7 | 3439329 | 366277 | 2730167 | 9389943 | 53 | 28 | 3496624 | 373221 | 2679372 | 32 | 48 | 3551070 | 379864 | 2632518 | 9348257 |
| 8 | 3442060 | 366607 | 2727710 | 9388942 | 52 | 29 | 3499349 | 373553 | 2676995 | 31 | 49 | 3553789 | 380197 | 2630213 | 9347223 |
| 9 | 3444791 | 366937 | 2725256 | 9387940 | 51 | 30 | 3502074 | 373884 | 2674621 | 30 | 50 | 3556508 | 380530 | 2627912 | 9346189 |
| 10 | 3447521 | 367268 | 2722807 | 9386938 | 50 | 31 | 3504798 | 374216 | 2672251 | 29 | 51 | 3559226 | 380863 | 2625614 | 9345154 |
| 11 | 3450252 | 367598 | 2720362 | 9385934 | 49 | 32 | 3507523 | 374547 | 2669885 | 28 | 52 | 3561944 | 381196 | 2623319 | 9344119 |
| 12 | 3452982 | 367928 | 2717920 | 9384930 | 48 | 33 | 3510246 | 374879 | 2667522 | 27 | 53 | 3564662 | 381529 | 2621028 | 9343082 |
| 13 | 3455712 | 368258 | 2715482 | 9383925 | 47 | 34 | 3512970 | 375211 | 2665163 | 26 | 54 | 3567380 | 381862 | 2618741 | 9342045 |
| 14 | 3458441 | 368589 | 2713048 | 9382920 | 46 | 35 | 3515693 | 375543 | 2662808 | 25 | 55 | 3570097 | 382196 | 2616457 | 9341007 |
| 15 | 3461171 | 368919 | 2710618 | 9381913 | 45 | 36 | 3518416 | 375875 | 2660456 | 24 | 56 | 3572814 | 382529 | 2614176 | 9339968 |
| 16 | 3463900 | 369250 | 2708192 | 9380906 | 44 | 37 | 3521139 | 376207 | 2658108 | 23 | 57 | 3575531 | 382863 | 2611899 | 9338928 |
| 17 | 3466628 | 369580 | 2705769 | 9379898 | 43 | 38 | 3523862 | 376539 | 2655764 | 22 | 58 | 3578248 | 383196 | 2609625 | 9337888 |
| 18 | 3469357 | 369911 | 2703351 | 9378889 | 42 | 39 | 3526584 | 376871 | 2653423 | 21 | 59 | 3580964 | 383530 | 2607355 | 9336846 |
| 19 | 3472085 | 370242 | 2700936 | 9377880 | 41 | 40 | 3529306 | 377203 | 2651086 | 20 | 60 | 3583679 | 383864 | 2605089 | 9335804 |
| 20 | 3474812 | 370572 | 2698525 | 9376869 | 40 | | | | | | | | | | |

Deg. 69.

Deg. 69.

Deg. 69.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

21 Deg.

21 Deg.

21 Deg.

| | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|----------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|----------|
| 0 | .3583679 | .3838664 | 2.605089 | .9335804 | 60 | 21 | .3640841 | .390889 | 2.558268 | .9313739 | 39 | 41 | .3694765 | .397611 | 2.515018 |
| 1 | .3586395 | .384197 | 2.602825 | .9334761 | 59 | 22 | .3643351 | .391224 | 2.556075 | .9312679 | 38 | 42 | .3697468 | .397948 | 2.512889 |
| 2 | .3589110 | .384531 | 2.600565 | .9333718 | 58 | 23 | .3646059 | .391560 | 2.553885 | .9311619 | 37 | 43 | .3700170 | .398285 | 2.510762 |
| 3 | .3591825 | .384865 | 2.598309 | .9332673 | 57 | 24 | .3648768 | .391895 | 2.551699 | .9310558 | 36 | 44 | .3702872 | .398622 | 2.508639 |
| 4 | .3594540 | .385199 | 2.596056 | .9331628 | 56 | 25 | .3651476 | .392231 | 2.549516 | .9309496 | 35 | 45 | .3705574 | .398959 | 2.506519 |
| 5 | .3597254 | .385533 | 2.593806 | .9330582 | 55 | 26 | .3654184 | .392567 | 2.547335 | .9308434 | 34 | 46 | .3708276 | .399296 | 2.504402 |
| 6 | .3599968 | .385867 | 2.591560 | .9329535 | 54 | 27 | .3656891 | .392902 | 2.545159 | .9307370 | 33 | 47 | .3710977 | .399634 | 2.502289 |
| 7 | .3602682 | .386202 | 2.589317 | .9328488 | 53 | 28 | .3659599 | .393238 | 2.542985 | .9306306 | 32 | 48 | .3713678 | .399971 | 2.500178 |
| 8 | .3605395 | .386536 | 2.587078 | .9327439 | 52 | 29 | .3662306 | .393574 | 2.540815 | .9305241 | 31 | 49 | .3716379 | .400308 | 2.498070 |
| 9 | .3608108 | .386870 | 2.584842 | .9326390 | 51 | 30 | .3665012 | .393910 | 2.538647 | .9304176 | 30 | 50 | .3719079 | .400646 | 2.495966 |
| 10 | .3610821 | .387205 | 2.582609 | .9325340 | 50 | 31 | .3667719 | .394246 | 2.536483 | .9303109 | 29 | 51 | .3721780 | .400984 | 2.493864 |
| 11 | .3613534 | .387539 | 2.580380 | .9324290 | 49 | 32 | .3670425 | .394582 | 2.534323 | .9302042 | 28 | 52 | .3724479 | .401321 | 2.491766 |
| 12 | .3616246 | .387874 | 2.578153 | .9323238 | 48 | 33 | .3673130 | .394918 | 2.532165 | .9300974 | 27 | 53 | .3727179 | .401659 | 2.489670 |
| 13 | .3618958 | .388209 | 2.575931 | .9322186 | 47 | 34 | .3675836 | .395255 | 2.530011 | .9299905 | 26 | 54 | .3729878 | .401997 | 2.487578 |
| 14 | .3621669 | .388543 | 2.573711 | .9321133 | 46 | 35 | .3678541 | .395591 | 2.527859 | .9298835 | 25 | 55 | .3732577 | .402335 | 2.485488 |
| 15 | .3624380 | .388878 | 2.571495 | .9320079 | 45 | 36 | .3681246 | .395928 | 2.525711 | .9297765 | 24 | 56 | .3735275 | .402673 | 2.483402 |
| 16 | .3627091 | .389213 | 2.569283 | .9319024 | 44 | 37 | .3683950 | .396264 | 2.523566 | .9296694 | 23 | 57 | .3737973 | .403011 | 2.481319 |
| 17 | .3629802 | .389548 | 2.567073 | .9317969 | 43 | 38 | .3686654 | .396601 | 2.521424 | .9295622 | 22 | 58 | .3740671 | .403349 | 2.479238 |
| 18 | .3632512 | .389883 | 2.564867 | .9316912 | 42 | 39 | .3689358 | .396937 | 2.519286 | .9294549 | 21 | 59 | .3743369 | .403687 | 2.477161 |
| 19 | .3635222 | .390218 | 2.562664 | .9315855 | 41 | 40 | .3692061 | .397274 | 2.517150 | .9293475 | 20 | 60 | .3746066 | .404026 | 2.475086 |
| 20 | .3637932 | .390554 | 2.560464 | .9314797 | 40 | | | | | | | | | | .9271839 |

Deg. 68.

Deg. 68.

Deg. 68.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 22 Deg. | | | | | | | | | | 22 Deg. | | | | | | | | | | 22 Deg. | | | | | | | | | |
|---------|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|---|-------|---------|---------|---------|---|---|-------|-------|---------|---------|---|
| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
| 0 | .3746066 | .404026 | 2.475086 | .9271839 | 60 | 21 | .3802634 | .411149 | 2.432204 | .9248782 | 39 | 41 | .3856377 | .417967 | 2.392531 | .9226503 | 19 | | | | | | | | | | | | |
| 1 | .3748763 | .404364 | 2.473015 | .9270748 | 59 | 22 | .3805324 | .411489 | 2.430193 | .9247676 | 38 | 42 | .3859060 | .418309 | 2.390576 | .9225381 | 18 | | | | | | | | | | | | |
| 2 | .3751459 | .404703 | 2.470947 | .9269658 | 58 | 23 | .3808014 | .411830 | 2.428186 | .9246568 | 37 | 43 | .3861744 | .418650 | 2.388625 | .9224258 | 17 | | | | | | | | | | | | |
| 3 | .3754156 | .405041 | 2.468881 | .9268566 | 57 | 24 | .3810704 | .412170 | 2.426181 | .9245460 | 36 | 44 | .3864427 | .418992 | 2.386675 | .9223134 | 16 | | | | | | | | | | | | |
| 4 | .3756852 | .405380 | 2.466819 | .9267474 | 56 | 25 | .3813393 | .412510 | 2.424180 | .9244351 | 35 | 45 | .3867110 | .419334 | 2.384729 | .9222010 | 15 | | | | | | | | | | | | |
| 5 | .3759547 | .405719 | 2.464759 | .9266380 | 55 | 26 | .3816082 | .412851 | 2.422181 | .9243242 | 34 | 46 | .3869792 | .419676 | 2.382785 | .9220884 | 14 | | | | | | | | | | | | |
| 6 | .3762243 | .406057 | 2.462703 | .9265286 | 54 | 27 | .3818770 | .413191 | 2.420185 | .9242131 | 33 | 47 | .3872474 | .420019 | 2.380844 | .9219758 | 13 | | | | | | | | | | | | |
| 7 | .3764938 | .406396 | 2.460649 | .9264192 | 53 | 28 | .3821459 | .413532 | 2.418191 | .9241020 | 32 | 48 | .3875156 | .420361 | 2.378906 | .9218632 | 12 | | | | | | | | | | | | |
| 8 | .3767632 | .406735 | 2.458598 | .9263096 | 52 | 29 | .3824147 | .413872 | 2.416201 | .9239908 | 31 | 49 | .3877837 | .420703 | 2.376970 | .9217504 | 11 | | | | | | | | | | | | |
| 9 | .3770327 | .407074 | 2.456551 | .9262000 | 51 | 30 | .3826834 | .414213 | 2.414213 | .9238795 | 30 | 50 | .3880518 | .421046 | 2.375037 | .9216375 | 10 | | | | | | | | | | | | |
| 10 | .3773021 | .407413 | 2.454506 | .9260902 | 50 | 31 | .3829522 | .414554 | 2.412228 | .9237682 | 29 | 51 | .3883199 | .421388 | 2.373106 | .9215246 | 9 | | | | | | | | | | | | |
| 11 | .3775714 | .407753 | 2.452464 | .9259805 | 49 | 32 | .3832209 | .414895 | 2.410246 | .9236567 | 28 | 52 | .3885880 | .421731 | 2.371179 | .9214116 | 8 | | | | | | | | | | | | |
| 12 | .3778408 | .408092 | 2.450425 | .9258706 | 48 | 33 | .3834895 | .415236 | 2.408267 | .9235452 | 27 | 53 | .3888560 | .422073 | 2.369254 | .9212986 | 7 | | | | | | | | | | | | |
| 13 | .3781101 | .408431 | 2.448389 | .9257606 | 47 | 34 | .3837582 | .415577 | 2.406290 | .9234336 | 26 | 54 | .3891240 | .422416 | 2.367331 | .9211854 | 6 | | | | | | | | | | | | |
| 14 | .3783794 | .408771 | 2.446355 | .9256506 | 46 | 35 | .3840268 | .415918 | 2.404316 | .9233220 | 25 | 55 | .3893919 | .422759 | 2.365411 | .9210722 | 5 | | | | | | | | | | | | |
| 15 | .3786486 | .409110 | 2.444325 | .9255405 | 45 | 36 | .3842953 | .416259 | 2.402345 | .9232102 | 24 | 56 | .3896598 | .423102 | 2.363494 | .9209589 | 4 | | | | | | | | | | | | |
| 16 | .3789178 | .409450 | 2.442298 | .9254303 | 44 | 37 | .3845639 | .416601 | 2.400377 | .9230984 | 23 | 57 | .3899277 | .423445 | 2.361580 | .9208455 | 3 | | | | | | | | | | | | |
| 17 | .3791870 | .409790 | 2.440273 | .9253201 | 43 | 38 | .3848324 | .416942 | 2.398411 | .9229865 | 22 | 58 | .3901955 | .423788 | 2.359668 | .9207320 | 2 | | | | | | | | | | | | |
| 18 | .3794562 | .410129 | 2.438251 | .9252097 | 42 | 39 | .3851008 | .417284 | 2.396449 | .9228745 | 21 | 59 | .3904633 | .424131 | 2.357759 | .9206185 | 1 | | | | | | | | | | | | |
| 19 | .3797253 | .410469 | 2.436233 | .9250993 | 41 | 40 | .3853693 | .417625 | 2.394488 | .9227624 | 20 | 60 | .3907311 | .424474 | 2.355852 | .9205049 | 0 | | | | | | | | | | | | |
| 20 | .3799944 | .410809 | 2.434217 | .9249888 | 40 | | | | | | | | | | | | | | | | | | | | | | | | |

Deg. 67.

D. g. 67.

Deg. 67.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—*continued.*

| 23 Deg. | | | | | | | | | | 23 Deg. | | | | | | | | | | 23 Deg. | | | | | | | | | |
|---------|---------|--------|---------|---------|---------|----|----------|--------|---------|---------|----|----|---------|--------|---------|---------|----|---|-------|---------|---------|---------|---|---|---------|-------|---------|---------|---|
| 23 Deg. | | | | | 23 Deg. | | | | | 23 Deg. | | | | | 23 Deg. | | | | | 23 Deg. | | | | | 23 Deg. | | | | |
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
| 0 | 3907311 | 424474 | 2355852 | 9205049 | 60 | 21 | 39633468 | 431703 | 2316407 | 9181009 | 39 | 41 | 4016814 | 438622 | 2279865 | 9157795 | 19 | | | | | | | | | | | | |
| 1 | 3909989 | 424818 | 2353948 | 9203912 | 59 | 22 | 3966139 | 432048 | 2314557 | 9179855 | 38 | 42 | 4019478 | 438969 | 2278063 | 9156626 | 18 | | | | | | | | | | | | |
| 2 | 3912666 | 425161 | 2352046 | 9202774 | 58 | 23 | 3968809 | 432393 | 2312709 | 9178701 | 37 | 43 | 4022141 | 439316 | 2276264 | 9155456 | 17 | | | | | | | | | | | | |
| 3 | 3915343 | 425505 | 2350148 | 9201635 | 57 | 24 | 3971479 | 432738 | 2310863 | 9177546 | 36 | 44 | 4024804 | 439663 | 2274467 | 9154286 | 16 | | | | | | | | | | | | |
| 4 | 3918019 | 425848 | 2348251 | 9200496 | 56 | 25 | 3974148 | 433084 | 2309020 | 9176391 | 35 | 45 | 4027467 | 440010 | 2272672 | 9153115 | 15 | | | | | | | | | | | | |
| 5 | 3920695 | 426192 | 2346358 | 9199356 | 55 | 26 | 3976818 | 433429 | 2307180 | 9175234 | 34 | 46 | 4030129 | 440357 | 2270880 | 9151943 | 14 | | | | | | | | | | | | |
| 6 | 3923371 | 426536 | 2344467 | 9198215 | 54 | 27 | 3979486 | 433775 | 2305342 | 9174077 | 33 | 47 | 4032791 | 440705 | 2269090 | 9150770 | 13 | | | | | | | | | | | | |
| 7 | 3926047 | 426880 | 2342578 | 9197073 | 53 | 28 | 3982155 | 434120 | 2303506 | 9172919 | 32 | 48 | 4035453 | 441052 | 2267303 | 9149597 | 12 | | | | | | | | | | | | |
| 8 | 3928722 | 427223 | 2340692 | 9195931 | 52 | 29 | 3984823 | 434466 | 2301673 | 9171760 | 31 | 49 | 4038114 | 441400 | 2265518 | 9148422 | 11 | | | | | | | | | | | | |
| 9 | 3931397 | 427568 | 2338809 | 9194788 | 51 | 30 | 3987491 | 434812 | 2299842 | 9170601 | 30 | 50 | 4040775 | 441747 | 2263735 | 9147247 | 10 | | | | | | | | | | | | |
| 10 | 3934071 | 427912 | 2336928 | 9193644 | 50 | 31 | 3990158 | 435158 | 2298014 | 9169440 | 29 | 51 | 4043436 | 442095 | 2261955 | 9146072 | 9 | | | | | | | | | | | | |
| 11 | 3936745 | 428256 | 2335050 | 9192499 | 49 | 32 | 3992825 | 435504 | 2296188 | 9168279 | 28 | 52 | 4046096 | 442443 | 2260177 | 9144895 | 8 | | | | | | | | | | | | |
| 12 | 3939419 | 428600 | 2333174 | 9191353 | 48 | 33 | 3995492 | 435850 | 2294365 | 9167118 | 27 | 53 | 4048756 | 442791 | 2258401 | 9143718 | 7 | | | | | | | | | | | | |
| 13 | 3942093 | 428944 | 2331301 | 9190207 | 47 | 34 | 3998158 | 436196 | 2292544 | 9165955 | 26 | 54 | 4051416 | 443139 | 2256628 | 9142540 | 6 | | | | | | | | | | | | |
| 14 | 3944766 | 429289 | 2329431 | 9189060 | 46 | 35 | 4000825 | 436542 | 2290725 | 9164791 | 25 | 55 | 4054075 | 443487 | 2254857 | 9141361 | 5 | | | | | | | | | | | | |
| 15 | 3947439 | 429633 | 2327563 | 9187912 | 45 | 36 | 4003490 | 436889 | 2288909 | 9163627 | 24 | 56 | 4056734 | 443835 | 2253088 | 9140181 | 4 | | | | | | | | | | | | |
| 16 | 3950111 | 429978 | 2325697 | 9186763 | 44 | 37 | 4006156 | 437235 | 2287095 | 9162462 | 23 | 57 | 4059393 | 444183 | 2251322 | 9139001 | 3 | | | | | | | | | | | | |
| 17 | 3952783 | 430323 | 2323834 | 9185614 | 43 | 38 | 4008821 | 437582 | 2285284 | 9161297 | 22 | 58 | 4062051 | 444531 | 2249558 | 9137819 | 2 | | | | | | | | | | | | |
| 18 | 3955455 | 430668 | 2321974 | 9184464 | 42 | 39 | 4011486 | 437928 | 2283475 | 9160130 | 21 | 59 | 4064709 | 444880 | 2247796 | 9136637 | 1 | | | | | | | | | | | | |
| 19 | 3958127 | 431012 | 2320116 | 9183313 | 41 | 40 | 4014150 | 438275 | 2281669 | 9158963 | 20 | 60 | 4067366 | 445228 | 2246036 | 9135455 | 0 | | | | | | | | | | | | |
| 20 | 3960798 | 431357 | 2318260 | 9182161 | 40 | | | | | | | | | | | | | | | | | | | | | | | | |

Deg. 66.

Deg. 66.

Deg. 66.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

24 Deg.

24 Deg.

24 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ° | Sine. | Tang. | Cotang. | Cosine. | ° | Sine. | Tang. | Cotang. | Cosine. | ° |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|----------|
| 0 | .4067366 | .445228 | 2.246036 | .9135455 | 60 | .21 | .4123096 | .452568 | 2.209611 | .9110438 | 39 | .41 | .4176028 | .459596 | 2.175822 |
| 1 | .4070024 | .445577 | 2.244279 | .9134271 | 59 | .22 | .4125745 | .452918 | 2.207901 | .9109238 | 38 | .42 | .4178671 | .459948 | 2.174155 |
| 2 | .4072681 | .445926 | 2.242524 | .9133087 | 58 | .23 | .4128395 | .453269 | 2.206193 | .9108038 | 37 | .43 | .4181313 | .460301 | 2.172491 |
| 3 | .4075337 | .446274 | 2.240772 | .9131902 | 57 | .24 | .4131044 | .453620 | 2.204487 | .9106837 | 36 | .44 | .4183956 | .460653 | 2.170828 |
| 4 | .4077993 | .446623 | 2.239021 | .9130716 | 56 | .25 | .4133693 | .453970 | 2.202784 | .9105635 | 35 | .45 | .4186597 | .461006 | 2.169167 |
| 5 | .4080649 | .446972 | 2.237273 | .9129529 | 55 | .26 | .4136342 | .454321 | 2.201083 | .9104432 | 34 | .46 | .4189239 | .461359 | 2.167509 |
| 6 | .4083305 | .447321 | 2.235528 | .9128342 | 54 | .27 | .4138990 | .454672 | 2.199384 | .9103228 | 33 | .47 | .4191880 | .461711 | 2.165852 |
| 7 | .4085960 | .447670 | 2.233784 | .9127154 | 53 | .28 | .4141638 | .455023 | 2.197687 | .9102024 | 32 | .48 | .4194521 | .462064 | 2.164198 |
| 8 | .4088615 | .448020 | 2.232043 | .9125965 | 52 | .29 | .4144285 | .455375 | 2.195992 | .9100819 | 31 | .49 | .4197161 | .462417 | 2.162546 |
| 9 | .4091269 | .448369 | 2.230304 | .9124775 | 51 | .30 | .4146932 | .455726 | 2.194299 | .9099613 | 30 | .50 | .4199801 | .462771 | 2.160895 |
| 10 | .4093923 | .448718 | 2.228567 | .9123584 | 50 | .31 | .4149579 | .456077 | 2.192609 | .9098406 | 29 | .51 | .4202441 | .463124 | 2.159247 |
| 11 | .4096577 | .449068 | 2.226833 | .9122393 | 49 | .32 | .4152226 | .456429 | 2.190921 | .9097199 | 28 | .52 | .4205080 | .463477 | 2.157601 |
| 12 | .4099230 | .449417 | 2.225100 | .9121201 | 48 | .33 | .4154872 | .456780 | 2.189234 | .9095990 | 27 | .53 | .4207719 | .463831 | 2.155957 |
| 13 | .4101883 | .449767 | 2.223370 | .9120008 | 47 | .34 | .4157517 | .457132 | 2.187551 | .9094781 | 26 | .54 | .4210358 | .464184 | 2.154315 |
| 14 | .4104536 | .450117 | 2.221643 | .9118815 | 46 | .35 | .4160163 | .457483 | 2.185869 | .9093572 | 25 | .55 | .4212966 | .464538 | 2.152675 |
| 15 | .4107189 | .450467 | 2.219917 | .9117620 | 45 | .36 | .4162808 | .457835 | 2.184189 | .9092361 | 24 | .56 | .4215634 | .464891 | 2.151037 |
| 16 | .4109841 | .450817 | 2.218194 | .9116425 | 44 | .37 | .4165453 | .458187 | 2.182511 | .9091150 | 23 | .57 | .4218272 | .465245 | 2.149402 |
| 17 | .4112492 | .451167 | 2.216473 | .9115229 | 43 | .38 | .4168097 | .458539 | 2.180836 | .9089938 | 22 | .58 | .4220909 | .465599 | 2.147768 |
| 18 | .4115144 | .451517 | 2.214754 | .9114033 | 42 | .39 | .4170741 | .458891 | 2.179163 | .9088725 | 21 | .59 | .4223546 | .465953 | 2.146136 |
| 19 | .4117795 | .451867 | 2.213037 | .9112835 | 41 | .40 | .4173385 | .459243 | 2.177492 | .9087511 | 20 | .60 | .4226183 | .466307 | 2.144506 |
| 20 | .4120445 | .452217 | 2.211323 | .9111637 | 40 | | | | | | | | | | |

Deg. 65.

Deg. 65.

Deg. 65.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 25 Deg. | | | | | | | | | | 25 Deg. | | | | | | | | | | 25 Deg. | | | | | | | | | | |
|---------|---------|---------|----------|----------|---------|----|----------|---------|----------|----------|---------|----|----------|---------|----------|----------|---------|---|---|---------|-------|---------|---------|---|---|-------|-------|---------|---------|---|
| / | | Sine. | Tang. | Cotang. | Cosine. | / | / | Sine. | Tang. | Cotang. | Cosine. | / | / | Sine. | Tang. | Cotang. | Cosine. | / | / | Sine. | Tang. | Cotang. | Cosine. | / | / | Sine. | Tang. | Cotang. | Cosine. | / |
| 0 | 4226183 | .466307 | 2.144506 | .9063078 | 60 | 21 | .4281467 | .473765 | 2.110747 | .9037093 | 39 | 41 | .4333970 | .480909 | 2.079394 | .9012031 | 19 | | | | | | | | | | | | | |
| 1 | 4228819 | .466661 | 2.142879 | .9061848 | 59 | 22 | .4284095 | .474122 | 2.109161 | .9035847 | 38 | 42 | .4336591 | .481267 | 2.077846 | .9010770 | 18 | | | | | | | | | | | | | |
| 2 | 4231455 | .467016 | 2.141253 | .9060618 | 58 | 23 | .4286723 | .474478 | 2.107577 | .9034600 | 37 | 43 | .4339212 | .481625 | 2.076300 | .9009508 | 17 | | | | | | | | | | | | | |
| 3 | 4234090 | .467370 | 2.139630 | .9059386 | 57 | 24 | .4289351 | .474834 | 2.105995 | .9033353 | 36 | 44 | .4341832 | .481984 | 2.074756 | .9008246 | 16 | | | | | | | | | | | | | |
| 4 | 4236725 | .467725 | 2.138008 | .9058154 | 56 | 25 | .4291979 | .475191 | 2.104415 | .9032105 | 35 | 45 | .4344453 | .482342 | 2.073214 | .9006982 | 15 | | | | | | | | | | | | | |
| 5 | 4239360 | .468079 | 2.136389 | .9056922 | 55 | 26 | .4294606 | .475548 | 2.102836 | .9030856 | 34 | 46 | .4347072 | .482701 | 2.071674 | .9005718 | 14 | | | | | | | | | | | | | |
| 6 | 4241994 | .468434 | 2.134771 | .9055688 | 54 | 27 | .4297233 | .475904 | 2.101260 | .9029606 | 33 | 47 | .4349692 | .483060 | 2.070135 | .9004453 | 13 | | | | | | | | | | | | | |
| 7 | 4244628 | .468789 | 2.133155 | .9054454 | 53 | 28 | .4299859 | .476261 | 2.099686 | .9028356 | 32 | 48 | .4352311 | .483418 | 2.068599 | .9003188 | 12 | | | | | | | | | | | | | |
| 8 | 4247262 | .469143 | 2.131542 | .9053219 | 52 | 29 | .4302485 | .476618 | 2.098114 | .9027105 | 31 | 49 | .4354930 | .483777 | 2.067064 | .9001921 | 11 | | | | | | | | | | | | | |
| 9 | 4249895 | .469498 | 2.129930 | .9051983 | 51 | 30 | .4305111 | .476975 | 2.096543 | .9025853 | 30 | 50 | .4357548 | .484136 | 2.065531 | .9000654 | 10 | | | | | | | | | | | | | |
| 10 | 4252528 | .469853 | 2.128321 | .9050746 | 50 | 31 | .4307736 | .477332 | 2.094975 | .9024600 | 29 | 51 | .4360166 | .484495 | 2.064000 | .8999386 | 9 | | | | | | | | | | | | | |
| 11 | 4255161 | .470209 | 2.126713 | .9049509 | 49 | 32 | .4310361 | .477689 | 2.093408 | .9023347 | 28 | 52 | .4362784 | .484855 | 2.062471 | .8998117 | 8 | | | | | | | | | | | | | |
| 12 | 4257793 | .470564 | 2.125108 | .9048271 | 48 | 33 | .4312986 | .478047 | 2.091843 | .9022092 | 27 | 53 | .4365401 | .485214 | 2.060944 | .8996848 | 7 | | | | | | | | | | | | | |
| 13 | 4260425 | .470919 | 2.123504 | .9047032 | 47 | 34 | .4315610 | .478404 | 2.090280 | .9020838 | 26 | 54 | .4368018 | .485573 | 2.059418 | .8995578 | 6 | | | | | | | | | | | | | |
| 14 | 4263056 | .471275 | 2.121903 | .9045792 | 46 | 35 | .4318234 | .478762 | 2.088720 | .9019582 | 25 | 55 | .4370634 | .485933 | 2.057895 | .8994307 | 5 | | | | | | | | | | | | | |
| 15 | 4265687 | .471630 | 2.120303 | .9044551 | 45 | 36 | .4320857 | .479119 | 2.087161 | .9018325 | 24 | 56 | .4373251 | .486293 | 2.056373 | .8993035 | 4 | | | | | | | | | | | | | |
| 16 | 4268318 | .471986 | 2.118705 | .9043310 | 44 | 37 | .4323481 | .479477 | 2.085603 | .9017068 | 23 | 57 | .4375866 | .486652 | 2.054853 | .8991763 | 3 | | | | | | | | | | | | | |
| 17 | 4270949 | .472342 | 2.117110 | .9042068 | 43 | 38 | .4326103 | .479835 | 2.084048 | .9015810 | 22 | 58 | .4378482 | .487012 | 2.053334 | .8990489 | 2 | | | | | | | | | | | | | |
| 18 | 4273579 | .472697 | 2.115516 | .9040825 | 42 | 39 | .4328726 | .480193 | 2.082495 | .9014551 | 21 | 59 | .4381097 | .487372 | 2.051818 | .8989215 | 1 | | | | | | | | | | | | | |
| 19 | 4276208 | .473053 | 2.113924 | .9039582 | 41 | 40 | .4331348 | .480551 | 2.080943 | .9013292 | 20 | 60 | .4383711 | .487732 | 2.050303 | .8987940 | 0 | | | | | | | | | | | | | |
| 20 | 4278838 | .473409 | 2.112334 | .9038338 | 40 | | | | | | | | | | | | | | | | | | | | | | | | | |

Deg. 64.

Deg. 64.

Deg. 64.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

26 Deg.

26 Deg.

26 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .4383711 | .487732 | 2.050303 | .8987940 | 60 | 21 | .4438534 | .495317 | 2.018908 | .8960094 | 39 | 41 | .4490591 | .502583 | 1.989720 | .8935021 | 19 |
| 1 | .4386326 | .488092 | 2.048791 | .8986665 | 59 | 22 | .4441140 | .495679 | 2.017433 | .8959703 | 38 | 42 | .4493190 | .502947 | 1.988278 | .8933714 | 18 |
| 2 | .4388940 | .488453 | 2.047280 | .8985389 | 58 | 23 | .4443746 | .496041 | 2.015959 | .8958411 | 37 | 43 | .4495789 | .503312 | 1.986838 | .8932406 | 17 |
| 3 | .4391553 | .488813 | 2.045770 | .8984112 | 57 | 24 | .4446352 | .496404 | 2.014486 | .8957118 | 36 | 44 | .4498387 | .503676 | 1.985400 | .8931098 | 16 |
| 4 | .4394166 | .489173 | 2.044263 | .8982834 | 56 | 25 | .4448957 | .496766 | 2.013016 | .8955824 | 35 | 45 | .4500984 | .504041 | 1.983963 | .8929789 | 15 |
| 5 | .4396779 | .489534 | 2.042757 | .8981555 | 55 | 26 | .4451562 | .497129 | 2.011547 | .8954529 | 34 | 46 | .4503582 | .504406 | 1.982528 | .8928480 | 14 |
| 6 | .4399392 | .489894 | 2.041254 | .8980276 | 54 | 27 | .4454167 | .497492 | 2.010080 | .8953234 | 33 | 47 | .4506179 | .504771 | 1.981095 | .8927169 | 13 |
| 7 | .4402004 | .490255 | 2.039751 | .8978996 | 53 | 28 | .4456771 | .497855 | 2.008615 | .8951938 | 32 | 48 | .4508775 | .505136 | 1.979663 | .8925858 | 12 |
| 8 | .4404615 | .490616 | 2.038251 | .8977715 | 52 | 29 | .4459375 | .498218 | 2.007151 | .8950641 | 31 | 49 | .4511372 | .505501 | 1.978233 | .8924546 | 11 |
| 9 | .4407227 | .490977 | 2.036753 | .8976433 | 51 | 30 | .4461978 | .498581 | 2.005689 | .8949344 | 30 | 50 | .4513967 | .505866 | 1.976805 | .8923234 | 10 |
| 10 | .4409838 | .491338 | 2.035256 | .8975151 | 50 | 31 | .4464581 | .498944 | 2.004229 | .8948045 | 29 | 51 | .4516563 | .506232 | 1.975378 | .8921920 | 9 |
| 11 | .4412448 | .491699 | 2.033761 | .8973868 | 49 | 32 | .4467184 | .499308 | 2.002771 | .8946746 | 28 | 52 | .4519158 | .506597 | 1.973953 | .8920606 | 8 |
| 12 | .4415059 | .492061 | 2.032268 | .8972584 | 48 | 33 | .4469786 | .499671 | 2.001314 | .8945446 | 27 | 53 | .4521753 | .506963 | 1.972529 | .8919291 | 7 |
| 13 | .4417668 | .492422 | 2.030776 | .8971299 | 47 | 34 | .4472388 | .500035 | 1.999859 | .8944146 | 26 | 54 | .4524341 | .507329 | 1.971107 | .8917975 | 6 |
| 14 | .4420278 | .492783 | 2.029287 | .8970014 | 46 | 35 | .4474990 | .500398 | 1.998405 | .8942844 | 25 | 55 | .4526941 | .507694 | 1.969687 | .8916659 | 5 |
| 15 | .4422887 | .493145 | 2.027799 | .8968727 | 45 | 36 | .4477591 | .500762 | 1.996953 | .8941542 | 24 | 56 | .4529535 | .508060 | 1.968268 | .8915342 | 4 |
| 16 | .4425496 | .493507 | 2.026313 | .8967440 | 44 | 37 | .4480192 | .501126 | 1.995503 | .8940240 | 23 | 57 | .4532128 | .508426 | 1.966851 | .8914024 | 3 |
| 17 | .4428104 | .493868 | 2.024828 | .8966153 | 43 | 38 | .4482792 | .501490 | 1.994055 | .8938936 | 22 | 58 | .4534721 | .508792 | 1.965436 | .8912705 | 2 |
| 18 | .4430712 | .494230 | 2.023346 | .8964864 | 42 | 39 | .4485392 | .501854 | 1.992608 | .8937632 | 21 | 59 | .4537313 | .509159 | 1.964022 | .8911385 | 1 |
| 19 | .4433319 | .494592 | 2.021865 | .8963575 | 41 | 40 | .4487992 | .502218 | 1.991163 | .8936326 | 20 | 60 | .4539905 | .509525 | 1.962610 | .8910065 | 0 |
| 20 | .4435927 | .494954 | 2.020386 | .8962285 | 40 | | | | | | | | | | | | |

Deg. 63.

Deg. 63.

Deg. 63.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1.—continued.

| 27 Deg. | | | | 27 Deg. | | | | 27 Deg. | | | | 27 Deg. | | | |
|---------|----------|---------|----------|----------|---------|----|----------|---------|----------|----------|----|---------|----------|---------|----------|
| ' | Sine. | Tang. | Cotang. | ' | Cosine. | ' | Sine. | ' | Tang. | Cotang. | ' | Sine. | ' | Tang. | Cotang. |
| 0 | .4539905 | .509525 | 1.962610 | .8910065 | 60 | 21 | .4594248 | | 1.933323 | .8882166 | 39 | 41 | .4645845 | .524640 | 1.906066 |
| 1 | .4542497 | .509891 | 1.961200 | .8908744 | 59 | 22 | .4596832 | | 1.931945 | .8880830 | 38 | 42 | .4648420 | .525011 | 1.904719 |
| 2 | .4545088 | .510258 | 1.959791 | .8907423 | 58 | 23 | .4599415 | | 1.930569 | .8879492 | 37 | 43 | .4650996 | .525382 | 1.903373 |
| 3 | .4547679 | .510625 | 1.958383 | .8906100 | 57 | 24 | .4601998 | | 1.929195 | .8878154 | 36 | 44 | .4653571 | .525754 | 1.902029 |
| 4 | .4550269 | .510991 | 1.956978 | .8904777 | 56 | 25 | .4604580 | | 1.927822 | .8876815 | 35 | 45 | .4656145 | .526125 | 1.900687 |
| 5 | .4552859 | .511358 | 1.955573 | .8903453 | 55 | 26 | .4607162 | | 1.926451 | .8875475 | 34 | 46 | .4658719 | .526496 | 1.899346 |
| 6 | .4555449 | .511725 | 1.954171 | .8902128 | 54 | 27 | .4609744 | | 1.925081 | .8874134 | 33 | 47 | .4661293 | .526868 | 1.898006 |
| 7 | .4558038 | .512093 | 1.952770 | .8900803 | 53 | 28 | .4612325 | | 1.923713 | .8872793 | 32 | 48 | .4663866 | .527240 | 1.896668 |
| 8 | .4560627 | .512460 | 1.951371 | .8899476 | 52 | 29 | .4614906 | | 1.922347 | .8871451 | 31 | 49 | .4666439 | .527612 | 1.895332 |
| 9 | .4563216 | .512827 | 1.949973 | .8898149 | 51 | 30 | .4617486 | | 1.920982 | .8870108 | 30 | 50 | .4669012 | .527983 | 1.893997 |
| 10 | .4565804 | .513195 | 1.948577 | .8896822 | 50 | 31 | .4620066 | | 1.919618 | .8868765 | 29 | 51 | .4671584 | .528356 | 1.892663 |
| 11 | .4568392 | .513562 | 1.947182 | .8895493 | 49 | 32 | .4622646 | | 1.918256 | .8867420 | 28 | 52 | .4674156 | .528728 | 1.891331 |
| 12 | .4570979 | .513930 | 1.945789 | .8894164 | 48 | 33 | .4625225 | | 1.916896 | .8866075 | 27 | 53 | .4676727 | .529100 | 1.890000 |
| 13 | .4573566 | .514298 | 1.944398 | .8892834 | 47 | 34 | .4627804 | | 1.915537 | .8864730 | 26 | 54 | .4679298 | .529472 | 1.888671 |
| 14 | .4576153 | .514666 | 1.943008 | .8891503 | 46 | 35 | .4630382 | | 1.914179 | .8863383 | 25 | 55 | .4681869 | .529845 | 1.887343 |
| 15 | .4578739 | .515033 | 1.941620 | .8890171 | 45 | 36 | .4632960 | | 1.912823 | .8862036 | 24 | 56 | .4684439 | .530217 | 1.886017 |
| 16 | .4581325 | .515401 | 1.940233 | .8888839 | 44 | 37 | .4635538 | | 1.911469 | .8860688 | 23 | 57 | .4687009 | .530590 | 1.884692 |
| 17 | .4583910 | .515770 | 1.938848 | .8887506 | 43 | 38 | .4638115 | | 1.910116 | .8859339 | 22 | 58 | .4689578 | .530963 | 1.883369 |
| 18 | .4586496 | .516138 | 1.937464 | .8886172 | 42 | 39 | .4640692 | | 1.908764 | .8857989 | 21 | 59 | .4692147 | .531336 | 1.882047 |
| 19 | .4589080 | .516506 | 1.936082 | .8884838 | 41 | 40 | .4643269 | | 1.907414 | .8856639 | 20 | 60 | .4694716 | .531709 | 1.880726 |
| 20 | .4591665 | .516875 | 1.934702 | .8883503 | 40 | | | | | | | | | | |
| ' | Cosine. | Cotan. | Tang. | ' | Sine. | ' | Cosine. | ' | Cotan. | Tang. | ' | Sine. | ' | Cotan. | ' |
| | | | | | | | | | | | | | | | |

Deg. 62.

Deg. 62.

Deg. 62.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

29 Deg.

28 Deg.

28 Deg.

| | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|----------|
| 0 | .4694716 | .531709 | 1.880726 | .8829476 | 60 | 21 | .4748564 | .539570 | .1853325 | .8800633 | 39 | 41 | .4799683 | .547106 | 1.827799 |
| 1 | .4697284 | .532082 | 1.879407 | .8828110 | 59 | 22 | .4751124 | .539946 | .1852035 | .8799251 | 38 | 42 | .4802235 | .547484 | 1.826537 |
| 2 | .4699852 | .532455 | 1.878089 | .8826743 | 58 | 23 | .4753683 | .540322 | .1850747 | .8797869 | 37 | 43 | .4804786 | .547862 | 1.825276 |
| 3 | .4702419 | .532829 | 1.876773 | .8825376 | 57 | 24 | .4756242 | .540698 | .1849461 | .8796486 | 36 | 44 | .4807337 | .548240 | 1.824017 |
| 4 | .4704986 | .533202 | 1.875458 | .8824007 | 56 | 25 | .4758801 | .541074 | .1848176 | .8795102 | 35 | 45 | .4809888 | .548618 | 1.822759 |
| 5 | .4707553 | .533576 | 1.874145 | .8822638 | 55 | 26 | .4761359 | .541450 | .1846892 | .8793717 | 34 | 46 | .4812438 | .548997 | 1.821502 |
| 6 | .4710119 | .533950 | 1.872833 | .8821269 | 54 | 27 | .4763917 | .541826 | .1845609 | .8792332 | 33 | 47 | .4814987 | .549375 | 1.820247 |
| 7 | .4712685 | .534324 | 1.871523 | .8819898 | 53 | 28 | .4766474 | .542202 | .1844328 | .8790946 | 32 | 48 | .4817537 | .549754 | 1.818993 |
| 8 | .4715250 | .534698 | 1.870214 | .8818527 | 52 | 29 | .4769031 | .542579 | .1843049 | .8789559 | 31 | 49 | .4820086 | .550133 | 1.817740 |
| 9 | .4717815 | .535072 | 1.868906 | .8817155 | 51 | 30 | .4771588 | .542955 | .1841770 | .8788171 | 30 | 50 | .4822634 | .550512 | 1.816489 |
| 10 | .4720380 | .535446 | 1.867600 | .8815782 | 50 | 31 | .4774144 | .543332 | .1840494 | .8786783 | 29 | 51 | .4825182 | .550891 | 1.815239 |
| 11 | .4722944 | .535820 | 1.866295 | .8814409 | 49 | 32 | .4776700 | .543709 | .1839218 | .8785394 | 28 | 52 | .4827730 | .551270 | 1.813990 |
| 12 | .4725508 | .536195 | 1.864992 | .8813035 | 48 | 33 | .4779255 | .544086 | .1837944 | .8784004 | 27 | 53 | .4830277 | .551650 | 1.812743 |
| 13 | .4728071 | .536569 | 1.863690 | .8811660 | 47 | 34 | .4781810 | .544463 | .1836671 | .8782613 | 26 | 54 | .4832824 | .552029 | 1.811496 |
| 14 | .4730634 | .536944 | 1.862389 | .8810284 | 46 | 35 | .4784364 | .544840 | .1835399 | .8781222 | 25 | 55 | .4835370 | .552409 | 1.810252 |
| 15 | .4733197 | .537319 | 1.861090 | .8808907 | 45 | 36 | .4786919 | .545217 | .1834129 | .8779830 | 24 | 56 | .4837916 | .552789 | 1.809008 |
| 16 | .4735759 | .537694 | 1.859792 | .8807530 | 44 | 37 | .4789472 | .545595 | .1832861 | .8778437 | 23 | 57 | .4840462 | .553168 | 1.807766 |
| 17 | .4738321 | .538069 | 1.858496 | .8806152 | 43 | 38 | .4792026 | .545972 | .1831593 | .8777043 | 22 | 58 | .4843007 | .553548 | 1.806525 |
| 18 | .4740882 | .538444 | 1.857201 | .8804774 | 42 | 39 | .4794579 | .546350 | .1830327 | .8775649 | 21 | 59 | .4845552 | .553928 | 1.805286 |
| 19 | .4743443 | .538819 | 1.855908 | .8803394 | 41 | 40 | .4797131 | .546728 | .1829062 | .8774254 | 20 | 60 | .4848096 | .554309 | 1.804047 |
| 20 | .4746004 | .539195 | 1.854615 | .8802014 | 40 | | | | | | | | | | |

Deg. 61.

Deg. 61.

Deg. 61.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

29 Deg.

29 Deg.

29 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ° | Sine. | Tang. | Cotang. | Cosine. | ° | Sine. | Tang. | Cotang. | Cosine. | ° |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----|-------|----------|---------|----------|----------|
| 0 | .4848096 | .554309 | 1.804047 | .8746197 | 60 | .21 | .4901433 | .562321 | .8716419 | 39 | .41 | .4952060 | .570004 | 1.754372 | .8687756 |
| 1 | .4850640 | .554689 | 1.802810 | .8744786 | 59 | .22 | .4903968 | .562704 | 1.777130 | 38 | .42 | .4954587 | .570389 | 1.753186 | .8686315 |
| 2 | .4853184 | .555069 | 1.801575 | .8743375 | 58 | .23 | .4906503 | .563087 | 1.775921 | 37 | .43 | .4957113 | .570775 | 1.752002 | .8684874 |
| 3 | .4855727 | .555450 | 1.800340 | .8741963 | 57 | .24 | .4909038 | .563471 | 1.774714 | 36 | .44 | .4959639 | .571161 | 1.750819 | .8683431 |
| 4 | .4858270 | .555831 | 1.799107 | .8740550 | 56 | .25 | .4911572 | .563854 | 1.773507 | 35 | .45 | .4962165 | .571547 | 1.749637 | .8681988 |
| 5 | .4860812 | .556211 | 1.797875 | .8739137 | 55 | .26 | .4914105 | .564237 | 1.772302 | 34 | .46 | .4964690 | .571933 | 1.748456 | .8680544 |
| 6 | .4863354 | .556592 | 1.796645 | .8737722 | 54 | .27 | .4916638 | .564621 | 1.771098 | 33 | .47 | .4967215 | .572319 | 1.747276 | .8679100 |
| 7 | .4865895 | .556973 | 1.795416 | .8736307 | 53 | .28 | .4919171 | .565005 | 1.769895 | 32 | .48 | .4969740 | .572705 | 1.746098 | .8677655 |
| 8 | .4868436 | .557355 | 1.794188 | .8734891 | 52 | .29 | .4921704 | .565388 | 1.768694 | 31 | .49 | .4972264 | .573091 | 1.744921 | .8676209 |
| 9 | .4870977 | .557736 | 1.792961 | .8733475 | 51 | .30 | .4924236 | .565772 | 1.767494 | 30 | .50 | .4974787 | .573478 | 1.743745 | .8674762 |
| 10 | .4873517 | .558117 | 1.791736 | .8732058 | 50 | .31 | .4926767 | .566156 | 1.766295 | 29 | .51 | .4977310 | .573864 | 1.742570 | .8673314 |
| 11 | .4876057 | .558499 | 1.790512 | .8730640 | 49 | .32 | .4929298 | .566541 | 1.765097 | 28 | .52 | .4979833 | .574251 | 1.741396 | .8671866 |
| 12 | .4878597 | .558881 | 1.789289 | .8729221 | 48 | .33 | .4931829 | .566925 | 1.763900 | 27 | .53 | .4982355 | .574638 | 1.740224 | .8670417 |
| 13 | .4881136 | .559262 | 1.788067 | .8727801 | 47 | .34 | .4934359 | .567309 | 1.762705 | 26 | .54 | .4984877 | .575025 | 1.739053 | .8668967 |
| 14 | .4883674 | .559644 | 1.786847 | .8726381 | 46 | .35 | .4936889 | .567694 | 1.761511 | 25 | .55 | .4987399 | .575412 | 1.737883 | .8667517 |
| 15 | .4886212 | .560026 | 1.785628 | .8724960 | 45 | .36 | .4939419 | .568079 | 1.760318 | 24 | .56 | .4989920 | .575799 | 1.736714 | .8666066 |
| 16 | .4888750 | .560409 | 1.784410 | .8723538 | 44 | .37 | .4941948 | .568463 | 1.759126 | 23 | .57 | .4992441 | .576187 | 1.735546 | .8664614 |
| 17 | .4891288 | .560791 | 1.783194 | .8722116 | 43 | .38 | .4944476 | .568848 | 1.757936 | 22 | .58 | .4994961 | .576574 | 1.734380 | .8663161 |
| 18 | .4893825 | .561173 | 1.781979 | .8720693 | 42 | .39 | .4947005 | .569233 | 1.756747 | 21 | .59 | .4997481 | .576962 | 1.733214 | .8661708 |
| 19 | .4896361 | .561556 | 1.780765 | .8719269 | 41 | .40 | .4949532 | .569619 | 1.755559 | 20 | .60 | .5000000 | .577350 | 1.732050 | .8660254 |
| 20 | .4898897 | .561939 | 1.779552 | .8717844 | 40 | | | | | | | | | | |

Deg. 60.

Deg. 60.

Deg. 60.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 30 Deg. | | | | 30 Deg. | | | | 30 Deg. | | | | 30 Deg. | | | | 30 Deg. | | | |
|---------|---------|--------|---------|---------|---------|----|---------|---------|---------|---------|---------|---------|---------|--------|---------|---------|---------|---|---|
| | | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' |
| 0 | 5000000 | 577350 | 1732080 | 8660254 | 60 | 21 | 5052809 | 585524 | 1707871 | 8629549 | 39 | 41 | 5102928 | 593363 | 1685308 | 8600007 | 19 | | |
| 1 | 5002519 | 577738 | 1730887 | 8658799 | 59 | 22 | 5055319 | 585914 | 1706732 | 8628079 | 38 | 42 | 5105429 | 593756 | 1684191 | 8598523 | 18 | | |
| 2 | 5005037 | 578126 | 1729726 | 8657344 | 58 | 23 | 5057828 | 586305 | 1705595 | 8626608 | 37 | 43 | 5107930 | 594150 | 1683076 | 8597037 | 17 | | |
| 3 | 5007556 | 578514 | 1728565 | 8655887 | 57 | 24 | 5060338 | 586696 | 1704458 | 8625137 | 36 | 44 | 5110431 | 594543 | 1681962 | 8595551 | 16 | | |
| 4 | 5010073 | 578902 | 1727406 | 8654430 | 56 | 25 | 5062846 | 587087 | 1703323 | 8623664 | 35 | 45 | 5112931 | 594937 | 1680848 | 8594064 | 15 | | |
| 5 | 5012591 | 579291 | 1726247 | 8652973 | 55 | 26 | 5065355 | 587478 | 1702189 | 8622191 | 34 | 46 | 5115431 | 595331 | 1679736 | 8592576 | 14 | | |
| 6 | 5015107 | 579679 | 1725090 | 8651514 | 54 | 27 | 5067863 | 587870 | 1701055 | 8620717 | 33 | 47 | 5117930 | 595725 | 1678625 | 8591088 | 13 | | |
| 7 | 5017624 | 580068 | 1723934 | 8650055 | 53 | 28 | 5070370 | 588261 | 1699923 | 8619243 | 32 | 48 | 5120429 | 596119 | 1677515 | 8589599 | 12 | | |
| 8 | 5020140 | 580457 | 1722779 | 8648595 | 52 | 29 | 5072877 | 588653 | 1698792 | 8617768 | 31 | 49 | 5122927 | 596514 | 1676406 | 8588109 | 11 | | |
| 9 | 5022655 | 580846 | 1721626 | 8647134 | 51 | 30 | 5075384 | 589045 | 1697663 | 8616292 | 30 | 50 | 5125425 | 596908 | 1675298 | 8586619 | 10 | | |
| 10 | 5025170 | 581235 | 1720473 | 8645673 | 50 | 31 | 5077890 | 589436 | 1696534 | 8614815 | 29 | 51 | 5127923 | 597303 | 1674192 | 8585127 | 9 | | |
| 11 | 5027685 | 581624 | 1719322 | 8644211 | 49 | 32 | 5080396 | 589828 | 1695406 | 8613337 | 28 | 52 | 5130420 | 597697 | 1673086 | 8583635 | 8 | | |
| 12 | 5030199 | 582013 | 1718172 | 8642748 | 48 | 33 | 5082901 | 590221 | 1694280 | 8611859 | 27 | 53 | 5132916 | 598092 | 1671981 | 8582143 | 7 | | |
| 13 | 5032713 | 582403 | 1717023 | 8641284 | 47 | 34 | 5085406 | 590613 | 1693155 | 8610380 | 26 | 54 | 5135413 | 598487 | 1670878 | 8580649 | 6 | | |
| 14 | 5035227 | 582793 | 1715875 | 8639820 | 46 | 35 | 5087910 | 591005 | 1692030 | 8608901 | 25 | 55 | 5137908 | 598882 | 1669775 | 8579155 | 5 | | |
| 15 | 5037740 | 583182 | 1714728 | 8638355 | 45 | 36 | 5090414 | 591398 | 1690907 | 8607420 | 24 | 56 | 5140404 | 599278 | 1668674 | 8577660 | 4 | | |
| 16 | 5040252 | 583572 | 1713582 | 8636889 | 44 | 37 | 5092918 | 591791 | 1689785 | 8605939 | 23 | 57 | 5142899 | 599673 | 1667574 | 8576164 | 3 | | |
| 17 | 5042765 | 583962 | 1712438 | 8635423 | 43 | 38 | 5095421 | 592183 | 1688664 | 8604457 | 22 | 58 | 5145393 | 600069 | 1666474 | 8574668 | 2 | | |
| 18 | 5045276 | 584352 | 1711294 | 8633956 | 42 | 39 | 5097924 | 592576 | 1687544 | 8602975 | 21 | 59 | 5147887 | 600464 | 1665376 | 8573171 | 1 | | |
| 19 | 5047788 | 584743 | 1710152 | 8632488 | 41 | 40 | 5100426 | 592969 | 1686426 | 8601491 | 20 | 60 | 5150381 | 600860 | 1664279 | 8571673 | 0 | | |
| 20 | 5050298 | 585133 | 1709011 | 8631019 | 40 | | | | | | | | | | | | | | |

Deg. 59.

Deg. 59.

Deg. 59.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

31 Deg.

31 Deg.

31 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|----------|
| 0 | .5150381 | .600860 | 1.664279 | .8571673 | 60 | .21 | .5202646 | .609205 | 1.641482 | 85.40051 | 39 | 41 | .5252241 | .617210 | 1.620192 |
| 1 | .5152874 | .601256 | 1.663183 | .8570174 | 59 | 22 | .5205130 | .609604 | 1.640408 | .8538538 | 38 | 42 | .5254717 | .617612 | 1.619138 |
| 2 | .5155367 | .601652 | 1.662088 | .8568675 | 58 | 23 | .5207613 | .610003 | 1.639335 | .8537023 | 37 | 43 | .5257191 | .618014 | 1.618085 |
| 3 | .5157859 | .602049 | 1.660994 | .8567175 | 57 | 24 | .5210096 | .610402 | 1.638263 | .8535508 | 36 | 44 | .5259665 | .618416 | 1.617033 |
| 4 | .5160351 | .602445 | 1.659901 | .8565674 | 56 | 25 | .5212579 | .610801 | 1.637191 | .8533992 | 35 | 45 | .5262139 | .618818 | 1.615982 |
| 5 | .5162842 | .602841 | 1.658809 | .8564173 | 55 | 26 | .5215061 | .611201 | 1.636121 | .8532475 | 34 | 46 | .5264613 | .619221 | 1.614932 |
| 6 | .5165333 | .603238 | 1.657718 | .8562671 | 54 | 27 | .5217543 | .611601 | 1.635052 | .8530958 | 33 | 47 | .5267085 | .619623 | 1.613882 |
| 7 | .5167824 | .603635 | 1.656629 | .8561168 | 53 | 28 | .5220024 | .612000 | 1.633984 | .8529440 | 32 | 48 | .5269558 | .620026 | 1.612834 |
| 8 | .5170314 | .604032 | 1.655540 | .8559664 | 52 | 29 | .5222505 | .612400 | 1.632917 | .8527921 | 31 | 49 | .5272030 | .620429 | 1.611787 |
| 9 | .5172804 | .604429 | 1.654452 | .8558160 | 51 | 30 | .5224986 | .612800 | 1.631851 | .8526402 | 30 | 50 | .5274502 | .620832 | 1.610741 |
| 10 | .5175293 | .604826 | 1.653365 | .8556655 | 50 | 31 | .5227468 | .613201 | 1.630786 | .8524881 | 29 | 51 | .5276973 | .621235 | 1.609696 |
| 11 | .5177782 | .605224 | 1.652280 | .8555149 | 49 | 32 | .5229945 | .613601 | 1.629722 | .8523360 | 28 | 52 | .5279443 | .621638 | 1.608652 |
| 12 | .5180270 | .605621 | 1.651196 | .8553643 | 48 | 33 | .5232424 | .614001 | 1.628659 | .8521839 | 27 | 53 | .5281914 | .622041 | 1.607609 |
| 13 | .5182758 | .606019 | 1.650112 | .8552135 | 47 | 34 | .5234903 | .614402 | 1.627597 | .8520316 | 26 | 54 | .5284383 | .622445 | 1.606567 |
| 14 | .5185246 | .606417 | 1.649030 | .8550627 | 46 | 35 | .5237381 | .614803 | 1.626536 | .8518793 | 25 | 55 | .5286853 | .622848 | 1.605526 |
| 15 | .5187733 | .606814 | 1.647949 | .8549119 | 45 | 36 | .5239859 | .615204 | 1.625476 | .8517269 | 24 | 56 | .5289322 | .623252 | 1.604485 |
| 16 | .5190219 | .607213 | 1.646868 | .8547609 | 44 | 37 | .5242336 | .615605 | 1.624417 | .8515745 | 23 | 57 | .5291790 | .623656 | 1.603446 |
| 17 | .5192705 | .607611 | 1.645789 | .8546099 | 43 | 38 | .5244813 | .616006 | 1.623359 | .8514219 | 22 | 58 | .5294258 | .624060 | 1.602408 |
| 18 | .5195191 | .608009 | 1.644711 | .8544588 | 42 | 39 | .5247290 | .616407 | 1.622302 | .8512693 | 21 | 59 | .5296726 | .624465 | 1.601370 |
| 19 | .5197676 | .608408 | 1.643633 | .8543077 | 41 | 40 | .5249766 | .616809 | 1.621246 | .8511167 | 20 | 60 | .5299193 | .624869 | 1.600334 |
| 20 | .5200161 | .608806 | 1.642557 | .8541564 | 40 | | | | | | | | | | .8480481 |

Deg. 58.

Deg. 58

Deg. 58.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

32 Deg.

32 Deg.

32 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|----------|---------|----|-------|---------|---------|----------|---------|-------|-------|---------|---------|----|
| 0 | 5299193 | 624869 | 1.600334 | 8480481 | 60 | 21 | 5350898 | 633395 | 1.578791 | 8447952 | 39 | 41 | 5399955 | 641577 | 19 |
| 1 | 5301659 | 625273 | 1.599299 | 8478939 | 59 | 22 | 5353355 | 633803 | 1.577776 | 8446395 | 38 | 42 | 5402403 | 641988 | 18 |
| 2 | 5304125 | 625678 | 1.598264 | 8477397 | 58 | 23 | 5355812 | 634211 | 1.576761 | 8444838 | 37 | 43 | 5404851 | 642399 | 17 |
| 3 | 5306591 | 626083 | 1.597231 | 8475853 | 57 | 24 | 5358268 | 634619 | 1.575747 | 8443279 | 36 | 44 | 5407298 | 642810 | 16 |
| 4 | 5309057 | 626488 | 1.596198 | 8474309 | 56 | 25 | 5360724 | 635027 | 1.574735 | 8441720 | 35 | 45 | 5409745 | 643221 | 15 |
| 5 | 5311521 | 626893 | 1.595167 | 8472765 | 55 | 26 | 5363179 | 635435 | 1.573723 | 8440161 | 34 | 46 | 5412191 | 643632 | 14 |
| 6 | 5313986 | 627298 | 1.594136 | 8471219 | 54 | 27 | 5365634 | 635844 | 1.572712 | 8438600 | 33 | 47 | 5414637 | 644044 | 13 |
| 7 | 5316450 | 627704 | 1.593107 | 8469673 | 53 | 28 | 5368089 | 636252 | 1.571702 | 8437039 | 32 | 48 | 5417082 | 644456 | 12 |
| 8 | 5318913 | 628109 | 1.592078 | 8468126 | 52 | 29 | 5370543 | 636661 | 1.570693 | 8435477 | 31 | 49 | 5419527 | 644867 | 11 |
| 9 | 5321376 | 628515 | 1.591050 | 8466579 | 51 | 30 | 5372996 | 637070 | 1.569685 | 8433914 | 30 | 50 | 5421971 | 645279 | 10 |
| 10 | 5323839 | 628921 | 1.590023 | 8465030 | 50 | 31 | 5375449 | 637479 | 1.568678 | 8432351 | 29 | 51 | 5424415 | 645691 | 9 |
| 11 | 5326301 | 629327 | 1.588997 | 8463481 | 49 | 32 | 5377902 | 637888 | 1.567672 | 8430787 | 28 | 52 | 5426859 | 646104 | 8 |
| 12 | 5328763 | 629733 | 1.587973 | 8461932 | 48 | 33 | 5380354 | 638297 | 1.566666 | 8429222 | 27 | 53 | 5429302 | 646516 | 7 |
| 13 | 5331224 | 630139 | 1.586949 | 8460381 | 47 | 34 | 5382806 | 638707 | 1.565662 | 8427657 | 26 | 54 | 5431744 | 646929 | 6 |
| 14 | 5333685 | 630546 | 1.585926 | 8458830 | 46 | 35 | 5385257 | 639116 | 1.564659 | 8426091 | 25 | 55 | 5434187 | 647341 | 5 |
| 15 | 5336145 | 630953 | 1.584904 | 8457278 | 45 | 36 | 5387708 | 639526 | 1.563656 | 8424524 | 24 | 56 | 5436628 | 647754 | 4 |
| 16 | 5338605 | 631359 | 1.583883 | 8455726 | 44 | 37 | 5390158 | 639936 | 1.562654 | 8422956 | 23 | 57 | 5439069 | 648167 | 3 |
| 17 | 5341065 | 631766 | 1.582862 | 8454172 | 43 | 38 | 5392608 | 640346 | 1.561654 | 8421388 | 22 | 58 | 5441510 | 648580 | 2 |
| 18 | 5343523 | 632173 | 1.581843 | 8452618 | 42 | 39 | 5395058 | 640756 | 1.560654 | 8419819 | 21 | 59 | 5443951 | 648994 | 1 |
| 19 | 5345982 | 632581 | 1.580825 | 8451064 | 41 | 40 | 5397507 | 641167 | 1.559655 | 8418249 | 20 | 60 | 5446390 | 649407 | 0 |
| 20 | 5348440 | 632988 | 1.579807 | 8449508 | 40 | | | | | | | | | | |

Deg. 57.

Deg. 57.

Deg. 57.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | | 33 Deg. | |
|---------|---------|---------|----------|---------|----|---------|---------|---------|----------|---------|----|---------|---------|---------|----------|---------|----|---------|-------|
| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. |
| 0 | 5446390 | 649407 | 1.539865 | 8386706 | 60 | 21 | 5497520 | 658127 | 1.519463 | 8353279 | 39 | 41 | 5546024 | 666496 | 1.500382 | 8321155 | 19 | | |
| 1 | 5448830 | 649821 | 1.538884 | 8388121 | 59 | 22 | 5499950 | 658544 | 1.518801 | 8351680 | 38 | 42 | 5548444 | 666917 | 1.499436 | 8319541 | 18 | | |
| 2 | 5451269 | 650235 | 1.537905 | 8389336 | 58 | 23 | 5502379 | 658961 | 1.517540 | 8350080 | 37 | 43 | 5548444 | 667337 | 1.498492 | 8317927 | 17 | | |
| 3 | 5453707 | 650649 | 1.536927 | 8390551 | 57 | 24 | 5504807 | 659378 | 1.516379 | 8348479 | 36 | 44 | 5550283 | 667758 | 1.497548 | 8316312 | 16 | | |
| 4 | 5456145 | 651063 | 1.535949 | 8390363 | 56 | 25 | 5507236 | 659796 | 1.515620 | 8346877 | 35 | 45 | 5555702 | 668178 | 1.496608 | 8314696 | 15 | | |
| 5 | 5458583 | 651477 | 1.534972 | 8390175 | 55 | 26 | 5509663 | 660213 | 1.514861 | 8345275 | 34 | 46 | 5558121 | 668599 | 1.495663 | 8313080 | 14 | | |
| 6 | 5461020 | 651891 | 1.533996 | 8389987 | 54 | 27 | 5512091 | 660631 | 1.513703 | 8343672 | 33 | 47 | 5560539 | 669020 | 1.494722 | 8311463 | 13 | | |
| 7 | 5463456 | 652306 | 1.533021 | 8389798 | 53 | 28 | 5514518 | 661049 | 1.512746 | 8342068 | 32 | 48 | 5562956 | 669441 | 1.493782 | 8309845 | 12 | | |
| 8 | 5465892 | 652721 | 1.532047 | 8389609 | 52 | 29 | 5516944 | 661467 | 1.511790 | 8340463 | 31 | 49 | 5565373 | 669863 | 1.492842 | 8308226 | 11 | | |
| 9 | 5468328 | 653136 | 1.531074 | 8389418 | 51 | 30 | 5519370 | 661885 | 1.510835 | 8338858 | 30 | 50 | 5567790 | 670284 | 1.491903 | 8306607 | 10 | | |
| 10 | 5470763 | 653551 | 1.530102 | 8389226 | 50 | 31 | 5521795 | 662302 | 1.509880 | 8337252 | 29 | 51 | 5570202 | 670706 | 1.490965 | 8304987 | 9 | | |
| 11 | 5473198 | 653966 | 1.529130 | 8389036 | 49 | 32 | 5524220 | 662722 | 1.508927 | 8335646 | 28 | 52 | 5572621 | 671128 | 1.490028 | 8303366 | 8 | | |
| 12 | 5475632 | 654381 | 1.528160 | 8388843 | 48 | 33 | 5526645 | 663141 | 1.507974 | 8334038 | 27 | 53 | 5575036 | 671550 | 1.489092 | 8301745 | 7 | | |
| 13 | 5478066 | 654797 | 1.527190 | 8388650 | 47 | 34 | 5529069 | 663560 | 1.507022 | 8332430 | 26 | 54 | 5577451 | 671972 | 1.488157 | 8300123 | 6 | | |
| 14 | 5480499 | 655212 | 1.526221 | 8388456 | 46 | 35 | 5531492 | 663979 | 1.506071 | 8330822 | 25 | 55 | 5579865 | 672394 | 1.487222 | 8298500 | 5 | | |
| 15 | 5482932 | 655628 | 1.525253 | 8388262 | 45 | 36 | 5533915 | 664398 | 1.505121 | 8329212 | 24 | 56 | 5582279 | 672816 | 1.486288 | 8296877 | 4 | | |
| 16 | 5485365 | 656044 | 1.524286 | 8388068 | 44 | 37 | 5536338 | 664817 | 1.504171 | 8327602 | 23 | 57 | 5584692 | 673239 | 1.485355 | 8295252 | 3 | | |
| 17 | 5487797 | 656460 | 1.523320 | 8387873 | 43 | 38 | 5538761 | 665237 | 1.503222 | 8325991 | 22 | 58 | 5587105 | 673662 | 1.484423 | 8293628 | 2 | | |
| 18 | 5490228 | 656877 | 1.522354 | 8387678 | 42 | 39 | 5541182 | 665657 | 1.502275 | 8324380 | 21 | 59 | 5589517 | 674085 | 1.483491 | 8292002 | 1 | | |

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

34 Deg.

34 Deg.

34 Deg.

| | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .5591929 | .674508 | 1.482561 | .8290376 | 60 | 21 | .5642467 | .683433 | 1.463200 | .8256062 | 39 | 41 | .5690403 | .692002 | 1.445081 | .8225096 | 19 |
| 1 | .5594340 | .674931 | 1.481631 | .8288749 | 59 | 22 | .5644869 | .683860 | 1.462287 | .8254420 | 38 | 42 | .5692795 | .692432 | 1.444183 | .8221440 | 18 |
| 2 | .5596751 | .675355 | 1.480702 | .8287121 | 58 | 23 | .5647270 | .684287 | 1.461374 | .8252778 | 37 | 43 | .5695187 | .692863 | 1.443286 | .8219784 | 17 |
| 3 | .5599162 | .675779 | 1.479773 | .8285493 | 57 | 24 | .5649670 | .684714 | 1.460463 | .8251135 | 36 | 44 | .5697577 | .693293 | 1.442389 | .8218127 | 16 |
| 4 | .5601572 | .676202 | 1.478846 | .8283864 | 56 | 25 | .5652070 | .685141 | 1.459552 | .8249491 | 35 | 45 | .5699968 | .693724 | 1.441494 | .8216469 | 15 |
| 5 | .5603981 | .676626 | 1.477919 | .8282234 | 55 | 26 | .5654469 | .685569 | 1.458642 | .8247847 | 34 | 46 | .5702357 | .694155 | 1.440599 | .8214811 | 14 |
| 6 | .5606390 | .677050 | 1.476993 | .8280603 | 54 | 27 | .5656868 | .685996 | 1.457732 | .8246202 | 33 | 47 | .5704747 | .694586 | 1.439704 | .8213152 | 13 |
| 7 | .5608798 | .677475 | 1.476068 | .8278972 | 53 | 28 | .5659267 | .686424 | 1.456824 | .8244556 | 32 | 48 | .5707136 | .695018 | 1.438811 | .8211492 | 12 |
| 8 | .5611206 | .677899 | 1.475144 | .8277340 | 52 | 29 | .5661665 | .686852 | 1.455916 | .8242909 | 31 | 49 | .5709524 | .695449 | 1.437918 | .8209832 | 11 |
| 9 | .5613614 | .678324 | 1.474221 | .8275708 | 51 | 30 | .5664062 | .687281 | 1.455009 | .8241262 | 30 | 50 | .5711912 | .695881 | 1.437026 | .8208170 | 10 |
| 10 | .5616021 | .678749 | 1.473298 | .8274074 | 50 | 31 | .5666459 | .687709 | 1.454102 | .8239614 | 29 | 51 | .5714299 | .696313 | 1.436135 | .8206509 | 9 |
| 11 | .5618428 | .679174 | 1.472376 | .8272440 | 49 | 32 | .5668856 | .688137 | 1.453197 | .8237965 | 28 | 52 | .5716686 | .696745 | 1.435245 | .8204846 | 8 |
| 12 | .5620834 | .679599 | 1.471455 | .8270806 | 48 | 33 | .5671252 | .688566 | 1.452292 | .8236316 | 27 | 53 | .5719073 | .697177 | 1.434355 | .8203183 | 7 |
| 13 | .5623239 | .680024 | 1.470535 | .8269170 | 47 | 34 | .5673648 | .688995 | 1.451388 | .8234666 | 26 | 54 | .5721459 | .697609 | 1.433466 | .8201519 | 6 |
| 14 | .5625645 | .680450 | 1.469615 | .8267534 | 46 | 35 | .5676043 | .689424 | 1.450485 | .8233015 | 25 | 55 | .5723844 | .698042 | 1.432578 | .8199854 | 5 |
| 15 | .5628049 | .680875 | 1.468696 | .8265897 | 45 | 36 | .5678437 | .689853 | 1.449582 | .8231364 | 24 | 56 | .5726229 | .698474 | 1.431690 | .8198189 | 4 |
| 16 | .5630453 | .681301 | 1.467778 | .8264260 | 44 | 37 | .5680832 | .690283 | 1.448680 | .8229712 | 23 | 57 | .5728614 | .698907 | 1.430803 | .8196523 | 3 |
| 17 | .5632857 | .681727 | 1.466861 | .8262622 | 43 | 38 | .5683225 | .690712 | 1.447779 | .8228059 | 22 | 58 | .5730998 | .699340 | 1.429917 | .8194856 | 2 |
| 18 | .5635260 | .682153 | 1.465945 | .8260983 | 42 | 39 | .5685619 | .691142 | 1.446879 | .8226405 | 21 | 59 | .5733381 | .699774 | 1.429032 | .8193189 | 1 |
| 19 | .5637663 | .682580 | 1.465029 | .8259343 | 41 | 40 | .5688011 | .691572 | 1.445980 | .8224751 | 20 | 60 | .5735764 | .700207 | 1.428148 | .8191520 | 0 |
| 20 | .5640066 | .683006 | 1.464114 | | 40 | | | | | | | | | | | | |

Deg. 55.

Deg. 55.

Deg. 55.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

35 Deg.

35 Deg.

35 Deg.

| ° | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .5735764 | .700207 | 1.428148 | .8191520 | 60 | 21 | .5785696 | .709350 | 1.409740 | .8156330 | 39 | 41 | .5833050 | .718131 | 1.392501 | .8122532 | 19 |
| 1 | .5738147 | .700641 | 1.427264 | .8189852 | 59 | 22 | .5788069 | .709787 | 1.408871 | .8154647 | 38 | 42 | .5835512 | .718572 | 1.391647 | .8120835 | 18 |
| 2 | .5740529 | .701074 | 1.426381 | .8188182 | 58 | 23 | .5790440 | .710225 | 1.408003 | .8152963 | 37 | 43 | .5837774 | .719014 | 1.390793 | .8119137 | 17 |
| 3 | .5742911 | .701508 | 1.425498 | .8186512 | 57 | 24 | .5792812 | .710663 | 1.407136 | .8151278 | 36 | 44 | .5840036 | .719455 | 1.389940 | .8117439 | 16 |
| 4 | .5745292 | .701943 | 1.424617 | .8184841 | 56 | 25 | .5795183 | .711100 | 1.406270 | .8149593 | 35 | 45 | .5842497 | .719897 | 1.389087 | .8115740 | 15 |
| 5 | .5747672 | .702377 | 1.423736 | .8183169 | 55 | 26 | .5797553 | .711539 | 1.405404 | .8147906 | 34 | 46 | .5844857 | .720338 | 1.388235 | .8114040 | 14 |
| 6 | .5750053 | .702811 | 1.422856 | .8181497 | 54 | 27 | .5799923 | .711977 | 1.404539 | .8146220 | 33 | 47 | .5847217 | .720780 | 1.387384 | .8112339 | 13 |
| 7 | .5752432 | .703246 | 1.421976 | .8179824 | 53 | 28 | .5802292 | .712415 | 1.403674 | .8144532 | 32 | 48 | .5849577 | .721222 | 1.386534 | .8110638 | 12 |
| 8 | .5754811 | .703681 | 1.421097 | .8178151 | 52 | 29 | .5804661 | .712854 | 1.402811 | .8142844 | 31 | 49 | .5851936 | .721665 | 1.385684 | .8108936 | 11 |
| 9 | .5757190 | .704116 | 1.420220 | .8176476 | 51 | 30 | .5807030 | .713293 | 1.401948 | .8141155 | 30 | 50 | .5854294 | .722107 | 1.384835 | .8107234 | 10 |
| 10 | .5759568 | .704551 | 1.419342 | .8174801 | 50 | 31 | .5809397 | .713732 | 1.401086 | .8139466 | 29 | 51 | .5856652 | .722550 | 1.383986 | .8105530 | 9 |
| 11 | .5761946 | .704986 | 1.418466 | .8173125 | 49 | 32 | .5811765 | .714171 | 1.400224 | .8137775 | 28 | 52 | .5859010 | .722993 | 1.383139 | .8103826 | 8 |
| 12 | .5764323 | .705422 | 1.417590 | .8171449 | 48 | 33 | .5814132 | .714610 | 1.399363 | .8136084 | 27 | 53 | .5861367 | .723436 | 1.382292 | .8102122 | 7 |
| 13 | .5766700 | .705858 | 1.416715 | .8169772 | 47 | 34 | .5816498 | .715050 | 1.398503 | .8134393 | 26 | 54 | .5863724 | .723879 | 1.381445 | .8100416 | 6 |
| 14 | .5769076 | .706294 | 1.415840 | .8168094 | 46 | 35 | .5818864 | .715489 | 1.397644 | .8132701 | 25 | 55 | .5866080 | .724322 | 1.380600 | .8098710 | 5 |
| 15 | .5771452 | .706730 | 1.414967 | .8166416 | 45 | 36 | .5821230 | .715929 | 1.396785 | .8131008 | 24 | 56 | .5868435 | .724766 | 1.379755 | .8097004 | 4 |
| 16 | .5773827 | .707166 | 1.414094 | .8164736 | 44 | 37 | .5823595 | .716369 | 1.395926 | .8129314 | 23 | 57 | .5870790 | .725210 | 1.378910 | .8095296 | 3 |
| 17 | .5776202 | .707602 | 1.413222 | .8163056 | 43 | 38 | .5825959 | .716810 | 1.395069 | .8127620 | 22 | 58 | .5873145 | .725654 | 1.378067 | .8093588 | 2 |
| 18 | .5778576 | .708039 | 1.412350 | .8161376 | 42 | 39 | .5828323 | .717250 | 1.394213 | .8125925 | 21 | 59 | .5875499 | .726098 | 1.377224 | .8091879 | 1 |
| 19 | .5780950 | .708476 | 1.411479 | .8159695 | 41 | 40 | .5830687 | .717691 | 1.393357 | .8124229 | 20 | 60 | .5877853 | .726542 | 1.376381 | .8090170 | 0 |
| 20 | .5783323 | .708913 | 1.410609 | .8158013 | 40 | | | | | | | | | | | | |

Deg. 54.

Deg. 54.

Deg. 54.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

36 Deg.

36 Deg.

36 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|----|---------|--------|---------|---------|----|
| 0 | 5877853 | 726542 | 1376381 | 8090170 | 60 | 21 | 5927163 | 735917 | 1358848 | 8054113 | 39 | 41 | 5973919 | 744924 | 1342417 | 8019495 | 19 |
| 1 | 5880206 | 726987 | 1375540 | 8088460 | 59 | 22 | 5929505 | 736366 | 1358020 | 8052389 | 38 | 42 | 5976251 | 745377 | 1341602 | 8017756 | 18 |
| 2 | 5882558 | 727431 | 1374699 | 8086749 | 58 | 23 | 5931847 | 736814 | 1357193 | 8050664 | 37 | 43 | 5978583 | 745829 | 1340788 | 8016018 | 17 |
| 3 | 5884910 | 727876 | 1373859 | 8085037 | 57 | 24 | 5934189 | 737263 | 1356367 | 8048938 | 36 | 44 | 5980915 | 746282 | 1339975 | 8014278 | 16 |
| 4 | 5887262 | 728321 | 1373019 | 8083325 | 56 | 25 | 5936530 | 737712 | 1355541 | 8047211 | 35 | 45 | 5983246 | 746735 | 1339162 | 8012538 | 15 |
| 5 | 5889613 | 728767 | 1372180 | 8081612 | 55 | 26 | 5938871 | 738162 | 1354716 | 8045484 | 34 | 46 | 5985577 | 747188 | 1338350 | 8010797 | 14 |
| 6 | 5891964 | 729212 | 1371342 | 8079899 | 54 | 27 | 5941211 | 738611 | 1353891 | 8043756 | 33 | 47 | 5987906 | 747642 | 1337538 | 8009056 | 13 |
| 7 | 5894314 | 729658 | 1370504 | 8078185 | 53 | 28 | 5943550 | 739061 | 1353068 | 8042028 | 32 | 48 | 5990236 | 748095 | 1336727 | 8007314 | 12 |
| 8 | 5896663 | 730104 | 1369667 | 8076470 | 52 | 29 | 5945889 | 739511 | 1352244 | 8040299 | 31 | 49 | 5992565 | 748549 | 1335917 | 8005571 | 11 |
| 9 | 5899012 | 730550 | 1368831 | 8074754 | 51 | 30 | 5948228 | 739961 | 1351422 | 8038569 | 30 | 50 | 5994893 | 749003 | 1335107 | 8003827 | 10 |
| 10 | 5901361 | 730996 | 1367995 | 8073038 | 50 | 31 | 5950566 | 740411 | 1350600 | 8036838 | 29 | 51 | 5997221 | 749457 | 1334298 | 8002083 | 9 |
| 11 | 5903709 | 731442 | 1367161 | 8071321 | 49 | 32 | 5952904 | 740861 | 1349779 | 8035107 | 28 | 52 | 5999549 | 749911 | 1333490 | 8000338 | 8 |
| 12 | 5906057 | 731889 | 1366326 | 8069603 | 48 | 33 | 5955241 | 741312 | 1348958 | 8033375 | 27 | 53 | 6001876 | 750366 | 1332682 | 7998593 | 7 |
| 13 | 5908404 | 732336 | 1365493 | 8067885 | 47 | 34 | 5957577 | 741763 | 1348139 | 8031642 | 26 | 54 | 6004202 | 750821 | 1331875 | 7996847 | 6 |
| 14 | 5910750 | 732783 | 1364660 | 8066166 | 46 | 35 | 5959913 | 742214 | 1347319 | 8029909 | 25 | 55 | 6006528 | 751276 | 1331068 | 7995100 | 5 |
| 15 | 5913096 | 733230 | 1363827 | 8064446 | 45 | 36 | 5962249 | 742665 | 1346501 | 8028175 | 24 | 56 | 6008854 | 751731 | 1330262 | 7993352 | 4 |
| 16 | 5915442 | 733677 | 1362996 | 8062726 | 44 | 37 | 5964584 | 743117 | 1345683 | 8026440 | 23 | 57 | 6011179 | 752186 | 1329457 | 7991604 | 3 |
| 17 | 5917787 | 734125 | 1362165 | 8061005 | 43 | 38 | 5966918 | 743568 | 1344865 | 8024705 | 22 | 58 | 6013503 | 752642 | 1328652 | 7989855 | 2 |
| 18 | 5920132 | 734573 | 1361335 | 8059283 | 42 | 39 | 5969252 | 744020 | 1344049 | 8022969 | 21 | 59 | 6015827 | 753098 | 1327848 | 7988105 | 1 |
| 19 | 5922476 | 735021 | 1360505 | 8057560 | 41 | 40 | 5971586 | 744472 | 1343233 | 8021232 | 20 | 60 | 6018150 | 753554 | 1327044 | 7986355 | 0 |
| 20 | 5924819 | 735469 | 1359676 | 8055837 | 40 | | | | | | | | | | | | |

Deg. 53.

Deg. 53.

Deg. 53.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 37 Deg. | | | | 37 Deg. | | | | 37 Deg. | | | | Deg. 52. | | | |
|---------|----------|---------|----------|----------|---------|----|----------|---------|----------|----------|---------|----------|----------|---------|----------|
| ' | Sine. | Tang. | Cotang. | ' | Cosine. | ' | Sine. | Tang. | Cotang. | ' | Cosine. | ' | Tang. | Cotang. | ' |
| 0 | .6018150 | .753554 | 1.327044 | .7986355 | 60 | 21 | .6066824 | .763175 | 1.310314 | .7949444 | 39 | 41 | .6112969 | .772423 | 1.294627 |
| 1 | .6020473 | .754010 | 1.326242 | .7984604 | 59 | 22 | .6069136 | .763636 | 1.309523 | .7947678 | 38 | 42 | .6115270 | .772887 | 1.293848 |
| 2 | .6022795 | .754466 | 1.325439 | .7982853 | 58 | 23 | .6071447 | .764096 | 1.308734 | .7945913 | 37 | 43 | .6117572 | .773352 | 1.293071 |
| 3 | .6025117 | .754923 | 1.324638 | .7981100 | 57 | 24 | .6073758 | .764557 | 1.307945 | .7944146 | 36 | 44 | .6119873 | .773817 | 1.292294 |
| 4 | .6027439 | .755379 | 1.323837 | .7979347 | 56 | 25 | .6076069 | .765018 | 1.307157 | .7942379 | 35 | 45 | .6122173 | .774282 | 1.291517 |
| 5 | .6029760 | .755836 | 1.323036 | .7977594 | 55 | 26 | .6078379 | .765480 | 1.306369 | .7940611 | 34 | 46 | .6124473 | .774748 | 1.290742 |
| 6 | .6032080 | .756294 | 1.322237 | .7975839 | 54 | 27 | .6080689 | .765941 | 1.305582 | .7938843 | 33 | 47 | .6126772 | .775213 | 1.289966 |
| 7 | .6034400 | .756751 | 1.321437 | .7974084 | 53 | 28 | .6082998 | .766403 | 1.304796 | .7937074 | 32 | 48 | .6129071 | .775679 | 1.289192 |
| 8 | .6036719 | .757209 | 1.320639 | .7972329 | 52 | 29 | .6085306 | .766864 | 1.304010 | .7935304 | 31 | 49 | .6131369 | .776145 | 1.288418 |
| 9 | .6039038 | .757666 | 1.319841 | .7970572 | 51 | 30 | .6087614 | .767327 | 1.303225 | .7933533 | 30 | 50 | .6133666 | .776611 | 1.287644 |
| 10 | .6041356 | .758124 | 1.319044 | .7968815 | 50 | 31 | .6089922 | .767789 | 1.302440 | .7931762 | 29 | 51 | .6135964 | .777078 | 1.286871 |
| 11 | .6043674 | .758582 | 1.318247 | .7967058 | 49 | 32 | .6092229 | .768251 | 1.301656 | .7929990 | 28 | 52 | .6138260 | .777544 | 1.286099 |
| 12 | .6045991 | .759041 | 1.317451 | .7965299 | 48 | 33 | .6094535 | .768714 | 1.300873 | .7928218 | 27 | 53 | .6140556 | .778011 | 1.285327 |
| 13 | .6048308 | .759499 | 1.316655 | .7963540 | 47 | 34 | .6096841 | .769177 | 1.300090 | .7926445 | 26 | 54 | .6142852 | .778478 | 1.284556 |
| 14 | .6050624 | .759958 | 1.315861 | .7961780 | 46 | 35 | .6099147 | .769640 | 1.299308 | .7924671 | 25 | 55 | .6145147 | .778946 | 1.283786 |
| 15 | .6052940 | .760417 | 1.315066 | .7960020 | 45 | 36 | .6101452 | .770103 | 1.298526 | .7922896 | 24 | 56 | .6147442 | .779413 | 1.283016 |
| 16 | .6055255 | .760876 | 1.314273 | .7958259 | 44 | 37 | .6103756 | .770567 | 1.297745 | .7921121 | 23 | 57 | .6149736 | .779881 | 1.282246 |
| 17 | .6057570 | .761336 | 1.313480 | .7956497 | 43 | 38 | .6106060 | .771030 | 1.296964 | .7919345 | 22 | 58 | .6152029 | .780349 | 1.281477 |
| 18 | .6059884 | .761795 | 1.312687 | .7954735 | 42 | 39 | .6108363 | .771494 | 1.296185 | .7917569 | 21 | 59 | .6154322 | .780817 | 1.280709 |
| 19 | .6062198 | .762255 | 1.311895 | .7952972 | 41 | 40 | .6110666 | .771958 | 1.295405 | .7915792 | 20 | 60 | .6156615 | .781285 | 1.279941 |
| 20 | .6064511 | .762715 | 1.311104 | .7951208 | 40 | | | | | | | | | | |
| ' | Cosine. | Cotan. | Tang. | Sine. | ' | ' | Cosine. | Cotan. | Tang. | ' | Sine. | ' | Tang. | Cotan. | ' |

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

38 Deg.

38 Deg.

38 Deg.

| | Sine. | Tang. | Cotang. | Cosine. | | Sine. | Tang. | Cotang. | Cosine. | | Sine. | Tang. | Cotang. | Cosine. | |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|----------|
| 0 | .6156615 | .781285 | 1.279941 | .7880108 | 60 | .21 | .6204636 | .791170 | 1.263950 | .7842352 | 39 | 41 | .6250156 | .800673 | 1.248948 |
| 1 | .6158907 | .781754 | 1.279174 | .7878316 | 59 | 22 | .6206917 | .791643 | 1.263195 | .7840547 | 38 | 42 | .6252427 | .801151 | 1.248204 |
| 2 | .6161198 | .782222 | 1.278407 | .7876524 | 58 | 23 | .6209198 | .792116 | 1.262440 | .7838741 | 37 | 43 | .6254696 | .801628 | 1.247460 |
| 3 | .6163489 | .782691 | 1.277641 | .7874732 | 57 | 24 | .6211478 | .792590 | 1.261686 | .7836933 | 36 | 44 | .6256966 | .802106 | 1.246716 |
| 4 | .6165780 | .783161 | 1.276876 | .7872939 | 56 | 25 | .6213757 | .793064 | 1.260932 | .7835127 | 35 | 45 | .6259235 | .802584 | 1.245974 |
| 5 | .6168069 | .783630 | 1.276111 | .7871145 | 55 | 26 | .6216036 | .793537 | 1.260179 | .7833320 | 34 | 46 | .6261503 | .803063 | 1.245232 |
| 6 | .6170359 | .784100 | 1.275347 | .7869350 | 54 | 27 | .6218314 | .794012 | 1.259426 | .7831511 | 33 | 47 | .6263771 | .803541 | 1.244490 |
| 7 | .6172648 | .784570 | 1.274583 | .7867555 | 53 | 28 | .6220592 | .794486 | 1.258674 | .7829702 | 32 | 48 | .6266038 | .804020 | 1.243749 |
| 8 | .6174936 | .785040 | 1.273820 | .7865759 | 52 | 29 | .6222870 | .794961 | 1.257923 | .7827892 | 31 | 49 | .6268305 | .804499 | 1.243008 |
| 9 | .6177224 | .785510 | 1.273057 | .7863963 | 51 | 30 | .6225146 | .795435 | 1.257172 | .7826082 | 30 | 50 | .6270571 | .804979 | 1.242268 |
| 10 | .6179511 | .785980 | 1.272295 | .7862165 | 50 | 31 | .6227423 | .795911 | 1.256421 | .7824270 | 29 | 51 | .6272837 | .805458 | 1.241529 |
| 11 | .6181798 | .786451 | 1.271534 | .7860367 | 49 | 32 | .6229698 | .796386 | 1.255672 | .7822459 | 28 | 52 | .6275102 | .805938 | 1.240790 |
| 12 | .6184084 | .786922 | 1.270773 | .7858569 | 48 | 33 | .6231974 | .796861 | 1.254922 | .7820646 | 27 | 53 | .6277366 | .806418 | 1.240051 |
| 13 | .6186370 | .787393 | 1.270013 | .7856770 | 47 | 34 | .6234248 | .797337 | 1.254174 | .7818833 | 26 | 54 | .6279631 | .806898 | 1.239313 |
| 14 | .6188655 | .787864 | 1.269253 | .7854970 | 46 | 35 | .6236522 | .797813 | 1.253426 | .7817019 | 25 | 55 | .6281894 | .807378 | 1.238576 |
| 15 | .6190939 | .788336 | 1.268494 | .7853169 | 45 | 36 | .6238796 | .798289 | 1.252678 | .7815205 | 24 | 56 | .6284157 | .807859 | 1.237839 |
| 16 | .6193224 | .788808 | 1.267735 | .7851368 | 44 | 37 | .6241069 | .798765 | 1.251931 | .7813390 | 23 | 57 | .6286420 | .808340 | 1.237103 |
| 17 | .6195507 | .789280 | 1.266977 | .7849566 | 43 | 38 | .6243342 | .799242 | 1.251184 | .7811574 | 22 | 58 | .6288682 | .808821 | 1.236367 |
| 18 | .6197790 | .789752 | 1.266219 | .7847764 | 42 | 39 | .6245614 | .799719 | 1.250438 | .7809757 | 21 | 59 | .6290943 | .809302 | 1.235631 |
| 19 | .6200073 | .790224 | 1.265462 | .7845961 | 41 | 40 | .6247885 | .800196 | 1.249693 | .7807940 | 20 | 60 | .6293204 | .809784 | 1.234897 |
| 20 | .6202355 | .790697 | 1.264706 | .7844157 | 40 | | | | | | | | | | |

Deg. 51.

Deg. 51.

Deg. 51.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

| 39 Deg. | | | | 39 Deg. | | | | 39 Deg. | | | | 39 Deg. | | | | |
|---------|---------|--------|----------|---------|----|---------|---------|---------|----------|---------|----|---------|---------|---------|----------|---------|
| Sine. | | Tang. | | Cotang. | | Cosine. | | Sine. | | Tang. | | Cotang. | | Cosine. | | |
| ' | ° | ' | ° | ' | ° | ' | ° | ' | ° | ' | ° | ' | ° | ' | ° | |
| 0 | 6293204 | 809784 | 1.234897 | 7771460 | 60 | 21 | 6340659 | 819948 | 1.219888 | 7732872 | 39 | 41 | 6385440 | 829724 | 1.205219 | 7695853 |
| 1 | 6295464 | 810265 | 1.234162 | 7769629 | 59 | 22 | 6342808 | 820435 | 1.218865 | 7731027 | 38 | 42 | 6387678 | 830216 | 1.204505 | 7693996 |
| 2 | 6297724 | 810747 | 1.233429 | 7767797 | 58 | 23 | 6345057 | 820922 | 1.218142 | 7729182 | 37 | 43 | 6389916 | 830707 | 1.203793 | 7692137 |
| 3 | 6299983 | 811230 | 1.232696 | 7765965 | 57 | 24 | 6347305 | 821409 | 1.217419 | 7727336 | 36 | 44 | 6392153 | 831199 | 1.203081 | 7690278 |
| 4 | 6302242 | 811712 | 1.231963 | 7764132 | 56 | 25 | 6349553 | 821896 | 1.216698 | 7725489 | 35 | 45 | 6394390 | 831691 | 1.202369 | 7688418 |
| 5 | 6304500 | 812195 | 1.231231 | 7762298 | 55 | 26 | 6351800 | 822384 | 1.215976 | 7723642 | 34 | 46 | 6396626 | 832183 | 1.201658 | 7686558 |
| 6 | 6306758 | 812678 | 1.230499 | 7760464 | 54 | 27 | 6354046 | 822871 | 1.215256 | 7721794 | 33 | 47 | 6398862 | 832675 | 1.200947 | 7684697 |
| 7 | 6309015 | 813161 | 1.229768 | 7758629 | 53 | 28 | 6356292 | 823359 | 1.214535 | 7719945 | 32 | 48 | 6401097 | 833168 | 1.200237 | 7682835 |
| 8 | 6311272 | 813644 | 1.229038 | 7756794 | 52 | 29 | 6358537 | 823847 | 1.213816 | 7718096 | 31 | 49 | 6403332 | 833661 | 1.199527 | 7680973 |
| 9 | 6313528 | 814128 | 1.228308 | 7754957 | 51 | 30 | 6360782 | 824335 | 1.213097 | 7716246 | 30 | 50 | 6405566 | 834154 | 1.198818 | 7679110 |
| 10 | 6315784 | 814611 | 1.227578 | 7753121 | 50 | 31 | 6363026 | 824825 | 1.212378 | 7714395 | 29 | 51 | 6407799 | 834648 | 1.198109 | 7677246 |
| 11 | 6318039 | 815095 | 1.226849 | 7751283 | 49 | 32 | 6365270 | 825314 | 1.211660 | 7712544 | 28 | 52 | 6410032 | 835141 | 1.197401 | 7675382 |
| 12 | 6320293 | 815580 | 1.226121 | 7749445 | 48 | 33 | 6367513 | 825803 | 1.210942 | 7710692 | 27 | 53 | 6412264 | 835635 | 1.196693 | 7673517 |
| 13 | 6322547 | 816064 | 1.225393 | 7747606 | 47 | 34 | 6369756 | 826292 | 1.210225 | 7708840 | 26 | 54 | 6414496 | 836129 | 1.195986 | 7671652 |
| 14 | 6324800 | 816549 | 1.224665 | 7745767 | 46 | 35 | 6371998 | 826782 | 1.209508 | 7706986 | 25 | 55 | 6416728 | 836624 | 1.195279 | 7669785 |
| 15 | 6327053 | 817034 | 1.223938 | 7743928 | 45 | 36 | 6374240 | 827271 | 1.208792 | 7705132 | 24 | 56 | 6418958 | 837118 | 1.194573 | 7667918 |
| 16 | 6329306 | 817519 | 1.223212 | 7742086 | 44 | 37 | 6376481 | 827762 | 1.208076 | 7703278 | 23 | 57 | 6421189 | 837613 | 1.193867 | 7666051 |
| 17 | 6331557 | 818004 | 1.222486 | 7740244 | 43 | 38 | 6378721 | 828252 | 1.207361 | 7701423 | 22 | 58 | 6423418 | 838108 | 1.193162 | 7664183 |
| 18 | 6333809 | 818490 | 1.221761 | 7738402 | 42 | 39 | 6380961 | 828742 | 1.206646 | 7699567 | 21 | 59 | 6425647 | 838604 | 1.192457 | 7662314 |
| 19 | 6336059 | 818976 | 1.221036 | 7736559 | 41 | 40 | 6383201 | 829233 | 1.205932 | 7697710 | 20 | 60 | 6427876 | 839099 | 1.191753 | 7660444 |
| 20 | 6338310 | 819462 | 1.220312 | 7734716 | 40 | | | | | | | | | | | |

Deg. 50.

Deg. 50.

Deg. 50.

Deg. 50.

Deg. 50.

Deg. 50.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

40 Deg.

40 Deg.

40 Deg.

| | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|-------|----------|---------|----------|----------|-------|-------|----------|---------|----------|
| 0 | .6427876 | .839099 | 1.191753 | .7660444 | 60 | 21 | .6474551 | .849563 | 1.177075 | .7621036 | 39 | 41 | .6518778 | .859629 | 1.163291 |
| 1 | .6430104 | .839595 | 1.191049 | .7658574 | 59 | 22 | .6476767 | .850064 | 1.176382 | .7619152 | 38 | 42 | .6520984 | .860135 | 1.162607 |
| 2 | .6432332 | .840091 | 1.190346 | .7656704 | 58 | 23 | .6478984 | .850565 | 1.175688 | .7617268 | 37 | 43 | .6523189 | .860641 | 1.161923 |
| 3 | .6434559 | .840587 | 1.189643 | .7654832 | 57 | 24 | .6481199 | .851066 | 1.174996 | .7615383 | 36 | 44 | .6525394 | .861148 | 1.161240 |
| 4 | .6436785 | .841084 | 1.188941 | .7652960 | 56 | 25 | .6483414 | .851568 | 1.174303 | .7613497 | 35 | 45 | .6527598 | .861655 | 1.160557 |
| 5 | .6439011 | .841581 | 1.188239 | .7651087 | 55 | 26 | .6485628 | .852070 | 1.173612 | .7611611 | 34 | 46 | .6529801 | .862162 | 1.159874 |
| 6 | .6441236 | .842078 | 1.187538 | .7649214 | 54 | 27 | .6487842 | .852572 | 1.172920 | .7609724 | 33 | 47 | .6532004 | .862669 | 1.159192 |
| 7 | .6443461 | .842575 | 1.186837 | .7647340 | 53 | 28 | .6490056 | .853075 | 1.172229 | .7607837 | 32 | 48 | .6534206 | .863176 | 1.158511 |
| 8 | .6445685 | .843073 | 1.186136 | .7645465 | 52 | 29 | .6492268 | .853577 | 1.171539 | .7605949 | 31 | 49 | .6536408 | .863684 | 1.157830 |
| 9 | .6447909 | .843570 | 1.185437 | .7643590 | 51 | 30 | .6494480 | .854080 | 1.170849 | .7604060 | 30 | 50 | .6538609 | .864192 | 1.157149 |
| 10 | .6450132 | .844068 | 1.184737 | .7641714 | 50 | 31 | .6496692 | .854583 | 1.170160 | .7602170 | 29 | 51 | .6540810 | .864700 | 1.156469 |
| 11 | .6452355 | .844567 | 1.184038 | .7639838 | 49 | 32 | .6498903 | .855087 | 1.169471 | .7600280 | 28 | 52 | .6543010 | .865209 | 1.155789 |
| 12 | .6454577 | .845065 | 1.183340 | .7637960 | 48 | 33 | .6501114 | .855591 | 1.168782 | .7598389 | 27 | 53 | .6545209 | .865718 | 1.155110 |
| 13 | .6456798 | .845564 | 1.182642 | .7636082 | 47 | 34 | .6503324 | .856095 | 1.168094 | .7596498 | 26 | 54 | .6547408 | .866227 | 1.154431 |
| 14 | .6459019 | .846063 | 1.181944 | .7634204 | 46 | 35 | .6505533 | .856599 | 1.167407 | .7594606 | 25 | 55 | .6549607 | .866736 | 1.153753 |
| 15 | .6461240 | .846562 | 1.181247 | .7632325 | 45 | 36 | .6507742 | .857103 | 1.166720 | .7592713 | 24 | 56 | .6551804 | .867246 | 1.153075 |
| 16 | .6463460 | .847062 | 1.180551 | .7630445 | 44 | 37 | .6509951 | .857608 | 1.166033 | .7590820 | 23 | 57 | .6554002 | .867755 | 1.152397 |
| 17 | .6465679 | .847561 | 1.179855 | .7628564 | 43 | 38 | .6512158 | .858113 | 1.165347 | .7588926 | 22 | 58 | .6556198 | .868265 | 1.151721 |
| 18 | .6467898 | .848061 | 1.179159 | .7626683 | 42 | 39 | .6514366 | .858618 | 1.164661 | .7587031 | 21 | 59 | .6558395 | .868776 | 1.151044 |
| 19 | .6470116 | .848561 | 1.178464 | .7624802 | 41 | 40 | .6516572 | .859124 | 1.163976 | .7585136 | 20 | 60 | .6560590 | .869286 | 1.150368 |
| 20 | .6472334 | .849062 | 1.177769 | .7622919 | 40 | | | | | | | | | | |

Deg. 49.

Deg. 49.

Deg. 49.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—*continued*.

41 Deg.

41 Deg.

41 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .6560590 | .869286 | 1.150368 | .3547096 | 60 | 21 | .6606570 | .880068 | 1.136274 | .7506879 | 39 | 41 | .6650131 | .890445 | 1.123032 | .7468317 | 19 |
| 1 | .6562785 | .869797 | 1.149692 | .7545187 | 59 | 22 | .6608754 | .880585 | 1.135608 | .7504957 | 38 | 42 | .6652304 | .890967 | 1.122375 | .7466382 | 18 |
| 2 | .6564980 | .870308 | 1.149017 | .7543278 | 58 | 23 | .6610936 | .881101 | 1.134942 | .7503034 | 37 | 43 | .6654475 | .891489 | 1.121718 | .7464446 | 17 |
| 3 | .6567174 | .870820 | 1.148342 | .7541368 | 57 | 24 | .6613119 | .881618 | 1.134277 | .7501111 | 36 | 44 | .6656646 | .892011 | 1.121061 | .7462510 | 16 |
| 4 | .6569367 | .871331 | 1.147668 | .7539457 | 56 | 25 | .6615300 | .882135 | 1.133612 | .7499187 | 35 | 45 | .6658817 | .892534 | 1.120405 | .7460574 | 15 |
| 5 | .6571560 | .871843 | 1.146994 | .7537546 | 55 | 26 | .6617482 | .882653 | 1.132947 | .7497262 | 34 | 46 | .6660987 | .893056 | 1.119749 | .7458636 | 14 |
| 6 | .6573752 | .872355 | 1.146321 | .7535634 | 54 | 27 | .6619662 | .883170 | 1.132283 | .7495337 | 33 | 47 | .6663156 | .893579 | 1.119094 | .7456699 | 13 |
| 7 | .6575944 | .872868 | 1.145648 | .7533721 | 53 | 28 | .6621842 | .883688 | 1.131620 | .7493411 | 32 | 48 | .6665325 | .894103 | 1.118439 | .7454760 | 12 |
| 8 | .6578135 | .873380 | 1.144976 | .7531808 | 52 | 29 | .6624022 | .884206 | 1.130957 | .7491484 | 31 | 49 | .6667493 | .894626 | 1.117784 | .7452821 | 11 |
| 9 | .6580326 | .873893 | 1.144304 | .7529894 | 51 | 30 | .6626200 | .884725 | 1.130294 | .7489557 | 30 | 50 | .6669661 | .895150 | 1.117130 | .7450881 | 10 |
| 10 | .6582516 | .874406 | 1.143632 | .7527980 | 50 | 31 | .6628379 | .885244 | 1.129632 | .7487629 | 29 | 51 | .6671828 | .895674 | 1.116476 | .7448941 | 9 |
| 11 | .6584706 | .874920 | 1.142961 | .7526065 | 49 | 32 | .6630557 | .885763 | 1.128970 | .7485701 | 28 | 52 | .6673994 | .896199 | 1.115823 | .7446999 | 8 |
| 12 | .6586895 | .875433 | 1.142290 | .7524149 | 48 | 33 | .6632734 | .886282 | 1.128308 | .7483772 | 27 | 53 | .6676160 | .896723 | 1.115170 | .7445058 | 7 |
| 13 | .6589083 | .875947 | 1.141620 | .7522233 | 47 | 34 | .6634910 | .886801 | 1.127647 | .7481842 | 26 | 54 | .6678326 | .897248 | 1.114518 | .7443115 | 6 |
| 14 | .6591271 | .876462 | 1.140950 | .7520316 | 46 | 35 | .6637087 | .887321 | 1.126987 | .7479912 | 25 | 55 | .6680490 | .897773 | 1.113866 | .7441173 | 5 |
| 15 | .6593458 | .876976 | 1.140281 | .7518398 | 45 | 36 | .6639262 | .887841 | 1.126327 | .7477981 | 24 | 56 | .6682655 | .898299 | 1.113214 | .7439229 | 4 |
| 16 | .6595645 | .877491 | 1.139612 | .7516480 | 44 | 37 | .6641437 | .888361 | 1.125667 | .7476049 | 23 | 57 | .6684818 | .898825 | 1.112563 | .7437285 | 3 |
| 17 | .6597831 | .878006 | 1.138944 | .7514561 | 43 | 38 | .6643612 | .888882 | 1.125008 | .7474171 | 22 | 58 | .6686981 | .899351 | 1.111912 | .7435340 | 2 |
| 18 | .6600017 | .878521 | 1.138276 | .7512641 | 42 | 39 | .6645785 | .889403 | 1.124349 | .7472184 | 21 | 59 | .6689144 | .899877 | 1.111262 | .7433394 | 1 |
| 19 | .6602202 | .879037 | 1.137608 | .7510721 | 41 | 40 | .6647959 | .889924 | 1.123690 | .7470251 | 20 | 60 | .6691306 | .900404 | 1.110612 | .7431448 | 0 |
| 20 | .6604386 | .879552 | 1.136941 | .7508800 | 40 | | | | | | | | | | | | |

Deg. 48.

Deg. 48.

Deg. 48.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—continued.

42 Deg.

42 Deg.

42 Deg.

| ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|----|----------|---------|----------|----------|----|
| 0 | .6691306 | .900404 | 1.10612 | .7431448 | 60 | 21 | .6736577 | .911526 | 1.097060 | .7390435 | 39 | 41 | .6779459 | .922235 | 1.084322 | .7351118 | 19 |
| 1 | .6693468 | .900930 | 1.10963 | .7429502 | 59 | 22 | .6738727 | .912059 | 1.096420 | .7388475 | 38 | 42 | .6781597 | .922773 | 1.083689 | .7349146 | 18 |
| 2 | .6695628 | .901458 | 1.109314 | .7427554 | 58 | 23 | .6740876 | .912592 | 1.095779 | .7386515 | 37 | 43 | .6783734 | .923312 | 1.083057 | .7347173 | 17 |
| 3 | .6697789 | .901985 | 1.108665 | .7425606 | 57 | 24 | .6743024 | .913125 | 1.095139 | .7384553 | 36 | 44 | .6785871 | .923851 | 1.082425 | .7345199 | 16 |
| 4 | .6699948 | .902513 | 1.108017 | .7423658 | 56 | 25 | .6745172 | .913659 | 1.094500 | .7382592 | 35 | 45 | .6788007 | .924390 | 1.081793 | .7343225 | 15 |
| 5 | .6702108 | .903041 | 1.107369 | .7421708 | 55 | 26 | .6747319 | .914192 | 1.093861 | .7380629 | 34 | 46 | .6790143 | .924930 | 1.081162 | .7341250 | 14 |
| 6 | .6704266 | .903569 | 1.106721 | .7419758 | 54 | 27 | .6749466 | .914727 | 1.093222 | .7378666 | 33 | 47 | .6792278 | .925470 | 1.080532 | .7339275 | 13 |
| 7 | .6706424 | .904097 | 1.106075 | .7417808 | 53 | 28 | .6751612 | .915261 | 1.092584 | .7376703 | 32 | 48 | .6794413 | .926010 | 1.079901 | .7337299 | 12 |
| 8 | .6708582 | .904626 | 1.105428 | .7415857 | 52 | 29 | .6753757 | .915796 | 1.091946 | .7374738 | 31 | 49 | .6796547 | .926550 | 1.079271 | .7335325 | 11 |
| 9 | .6710739 | .905155 | 1.104782 | .7413905 | 51 | 30 | .6755902 | .916331 | 1.091308 | .7372773 | 30 | 50 | .6798681 | .927091 | 1.078642 | .7333345 | 10 |
| 10 | .6712895 | .905683 | 1.104136 | .7411953 | 50 | 31 | .6758046 | .916866 | 1.090671 | .7370808 | 29 | 51 | .6800813 | .927632 | 1.078013 | .7331367 | 9 |
| 11 | .6715051 | .906214 | 1.103491 | .7410000 | 49 | 32 | .6760190 | .917402 | 1.090034 | .7368842 | 28 | 52 | .6802946 | .928173 | 1.077384 | .7329388 | 8 |
| 12 | .6717206 | .906744 | 1.102846 | .7408046 | 48 | 33 | .6762333 | .917937 | 1.089396 | .7366875 | 27 | 53 | .6805078 | .928715 | 1.076756 | .7327409 | 7 |
| 13 | .6719361 | .907274 | 1.102201 | .7406092 | 47 | 34 | .6764476 | .918474 | 1.088752 | .7364908 | 26 | 54 | .6807209 | .929257 | 1.076128 | .7325429 | 6 |
| 14 | .6721515 | .907805 | 1.101557 | .7404137 | 46 | 35 | .6766618 | .919017 | 1.088126 | .7362940 | 25 | 55 | .6809339 | .929799 | 1.075500 | .7323449 | 5 |
| 15 | .6723668 | .908336 | 1.100914 | .7402181 | 45 | 36 | .6768760 | .919547 | 1.087491 | .7360971 | 24 | 56 | .6811469 | .930342 | 1.074873 | .7321467 | 4 |
| 16 | .6725821 | .908867 | 1.100270 | .7400225 | 44 | 37 | .6770901 | .920084 | 1.086857 | .7359002 | 23 | 57 | .6813599 | .930884 | 1.074246 | .7319486 | 3 |
| 17 | .6727973 | .909398 | 1.199628 | .7398268 | 43 | 38 | .6773041 | .920621 | 1.086222 | .7357032 | 22 | 58 | .6815728 | .931428 | 1.073620 | .7317503 | 2 |
| 18 | .6730125 | .909930 | 1.198985 | .7396311 | 42 | 39 | .6775181 | .921159 | 1.085588 | .7355061 | 21 | 59 | .6817856 | .931971 | 1.072994 | .7315521 | 1 |
| 19 | .6732276 | .910461 | 1.198343 | .7394353 | 41 | 40 | .6777320 | .921696 | 1.084955 | .7353090 | 20 | 60 | .6819984 | .932515 | 1.072368 | .7313537 | 0 |
| 20 | .6734427 | .910994 | 1.197702 | .7392394 | 40 | | | | | | | | | | | | |

Deg. 47.

Deg. 47.

Deg. 47.

IV.—NATURAL SINES AND TANGENTS TO A RADIUS 1—*continued*.

43 Deg

43 Deg.

43 Deg.

| ° | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' | ' | Sine. | Tang. | Cotang. | Cosine. | ' |
|----|---------|---------|----------|----------|---------|----|----------|---------|----------|----------|---------|----|----------|---------|----------|----------|---------|---|
| 0 | 6819984 | -932515 | 1-072368 | -7313537 | 60 | 21 | -6864532 | -944001 | 1-059320 | -7271740 | 39 | 41 | -6906721 | -955064 | 1-047049 | -7231681 | 19 | |
| 1 | 6822111 | -933059 | 1-071743 | -7311553 | 59 | 22 | -6866647 | -944551 | 1-058703 | -7269743 | 38 | 42 | -6908824 | -955620 | 1-046440 | -7229671 | 18 | |
| 2 | 6824237 | -933603 | 1-071118 | -7309568 | 58 | 23 | -6868761 | -945102 | 1-058086 | -7267745 | 37 | 43 | -6910927 | -956177 | 1-045831 | -7227661 | 17 | |
| 3 | 6826363 | -934147 | 1-070494 | -7307583 | 57 | 24 | -6870875 | -945653 | 1-057470 | -7265747 | 36 | 44 | -6913029 | -956734 | 1-045222 | -7225651 | 16 | |
| 4 | 6828489 | -934692 | 1-069870 | -7305597 | 56 | 25 | -6872988 | -946204 | 1-056854 | -7263748 | 35 | 45 | -6915131 | -957291 | 1-044613 | -7223640 | 15 | |
| 5 | 6830613 | -935238 | 1-069246 | -7303610 | 55 | 26 | -6875101 | -946755 | 1-056238 | -7261748 | 34 | 46 | -6917232 | -957849 | 1-044005 | -7221628 | 14 | |
| 6 | 6832738 | -935783 | 1-068623 | -7301623 | 54 | 27 | -6877213 | -947307 | 1-055623 | -7259748 | 33 | 47 | -6919332 | -958407 | 1-043397 | -7219615 | 13 | |
| 7 | 6834861 | -936329 | 1-068000 | -7299635 | 53 | 28 | -6879325 | -947859 | 1-055008 | -7257747 | 32 | 48 | -6921432 | -958965 | 1-042790 | -7217602 | 12 | |
| 8 | 6836984 | -936875 | 1-067377 | -7297646 | 52 | 29 | -6881435 | -948411 | 1-054394 | -7255746 | 31 | 49 | -6923531 | -959524 | 1-042183 | -7215589 | 11 | |
| 9 | 6839107 | -937421 | 1-066755 | -7295657 | 51 | 30 | -6883546 | -948964 | 1-053780 | -7253744 | 30 | 50 | -6925630 | -960082 | 1-041576 | -7213574 | 10 | |
| 10 | 6841229 | -937968 | 1-066134 | -7293668 | 50 | 31 | -6885655 | -949517 | 1-053166 | -7251741 | 29 | 51 | -6927728 | -960642 | 1-040970 | -7211559 | 9 | |
| 11 | 6843350 | -938515 | 1-065512 | -7291677 | 49 | 32 | -6887765 | -950070 | 1-052553 | -7249738 | 28 | 52 | -6929825 | -961201 | 1-040364 | -7209544 | 8 | |
| 12 | 6845471 | -939062 | 1-064891 | -7289686 | 48 | 33 | -6889873 | -950624 | 1-051940 | -7247734 | 27 | 53 | -6931922 | -961761 | 1-039758 | -7207528 | 7 | |
| 13 | 6847591 | -939610 | 1-064271 | -7287695 | 47 | 34 | -6891981 | -951178 | 1-051327 | -7245729 | 26 | 54 | -6934018 | -962321 | 1-039153 | -7205511 | 6 | |
| 14 | 6849711 | -940157 | 1-063651 | -7285703 | 46 | 35 | -6894089 | -951732 | 1-050715 | -7243724 | 25 | 55 | -6936114 | -962881 | 1-038548 | -7203494 | 5 | |
| 15 | 6851830 | -940706 | 1-063031 | -7283710 | 45 | 36 | -6896195 | -952287 | 1-050103 | -7241719 | 24 | 56 | -6938209 | -963442 | 1-037944 | -7201476 | 4 | |
| 16 | 6853948 | -941254 | 1-062411 | -7281716 | 44 | 37 | -6898302 | -952842 | 1-049492 | -7239712 | 23 | 57 | -6940304 | -964003 | 1-037340 | -7199457 | 3 | |
| 17 | 6856066 | -941803 | 1-061792 | -7279722 | 43 | 38 | -6900407 | -953397 | 1-048880 | -7237705 | 22 | 58 | -6942398 | -964565 | 1-036736 | -7197438 | 2 | |
| 18 | 6858184 | -942352 | 1-061174 | -7277728 | 42 | 39 | -6902512 | -953952 | 1-048270 | -7235698 | 21 | 59 | -6944491 | -965126 | 1-036133 | -7195418 | 1 | |
| 19 | 6860300 | -942901 | 1-060556 | -7275732 | 41 | 40 | -6904617 | -954508 | 1-047659 | -7233690 | 20 | 60 | -6946584 | -965688 | 1-035530 | -7193398 | 0 | |
| 20 | 8662416 | -943451 | 1-059938 | -7273736 | 40 | | | | | | | | | | | | | |

Deg. 46.

Deg. 46.

Deg. 46.